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CARBON MONOXIDE. A BIBLIOGRAPHY WITH ABSTRACTS

Anna Grossman Cooper

Public Health Service
Washington, D. C.

1966

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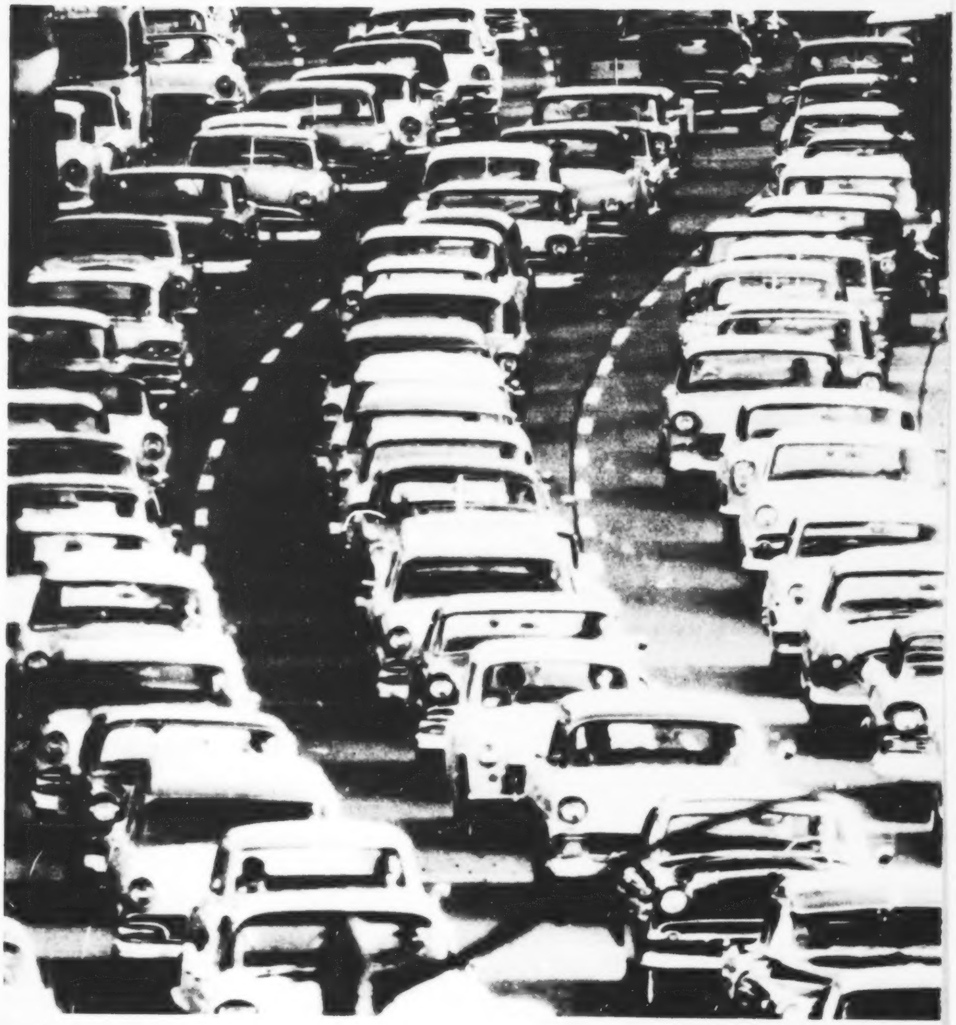

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An annotated bibliography is presented which deals with the effect of carbon monoxide on human health. The bibliography presents information in an effort to aid in the evaluation of the existing knowledge regarding carbon monoxide and, in further research on its biological and environmental effects and, in the establishment of air quality criteria. The abstracts which includes publications from 1880 to 1966, are listed under the following headings: Analysis; Biological Effects; Blood Chemistry; Control; Criteria and Standards; Instruments and Techniques; Sampling and Network Operations; and Sources.

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A BIBLIOGRAPHY WITH ABSTRACTS

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TABLE OF CONTENTS

PREFACE v

INTRODUCTION viii

BIBLIOGRAPHICAL LISTINGS

ANALYSIS 1

BIOLOGICAL EFFECTS 49
  Animals 49
    effect of acute (short term and severe) concentrations 49
    effect of chronic (long term and low) concentrations 59
  Humans 67
    effect of acute (short term and severe) concentrations 67
    effect of chronic (long term and low) concentrations 84
    experimental exposures 104
  Biochemistry and Biophysiology 110
  Cardiac Impairment 124
  Cerebral Effects 128
  EEG Patterns 135
  EKG Patterns 138
  Lung Diffusion 142
  Neurological Changes 160
  Postmortem Investigations 172
  Smoking 176
  Tissue Chemistry 185
  Vision Impairment 193

BLOOD CHEMISTRY 200
  Hemoglobin 200
  Method of Detection 241

CONTROL 260

CRITERIA AND STANDARDS 270

INSTRUMENTS AND TECHNIQUES 285

SAMPLING AND NETWORK OPERATIONS 308

SOURCES 316
  Aircraft Cabins, Submarines and Others 316
  Diesel Engines 324
  Garages and Workshops 328
  Gasoline Engines 337
  Tunnels 374

ADDITIONAL REFERENCES 388
  Books 388
  Legislation 400
  Review Papers 408

STATE REPORTS 419

CITY-COUNTY REPORTS 420

INTER-STATE REPORTS 423

MISCELLANEOUS REFERENCES 424

AUTHOR INDEX 427

GEOGRAPHIC LOCATION INDEX 437
  United States 437
  Foreign 437

GLOSSARY OF ABBREVIATIONS 439

PREFACE

In screening the literature for this bibliography, the compiler became aware of an immense wealth of papers on this subject, practically from the time combustion became known to man. According to the legend, described by many poets, Prometheus gave fire to man, warming not only man's body but also his mind, kindling in it a devouring faith in knowledge and progress. Man learned fast, and it did not take him long to discover the adverse aspects of combustion, including the toxic properties which were exploited early in history and not always for the best of purposes. In following the history of carbon monoxide, one finds it entwined with the history of mankind. The interesting book of Louis Lewin on the toxicology of carbon monoxide, for example, is also a book of history. Carbon monoxide forms a part of volcanic gases, and the mythological gods produced it in their forges. In ancient Rome, he who felt that there was no way left except to "cross the bridge of death" sought its aid in the fumes of charcoal. But not only was carbon monoxide used in suicide in antiquity, it was also used for punishment at the time of Cicero (106-43 B.C.).

Reference to the effect of carbon monoxide on the health of man are found in the writings on natural history by the Greek philosopher Aristoteles, who lived in the Third Century.

Erasistratus, a Greek physician and writer, also of the Third Century, who is known for his theory of the pneuma as a substance vital to life, expressed his ideas on the toxic properties of carbon monoxide in a hypothesis on causes and effects, stating that the thinness of the air caused by carbon monoxide fumes obstructed the normal breathing of man.

In a statement by another physician of the same Century, Caeluis Aurelianus, two most important symptoms caused by carbon monoxide are discussed, the disturbance of motion and the senses in general. "...It is not easy to be aware of the danger which is effected by the oppression of the senses through turpur of carbon..."

Another scientist of that time wrote on the physiological effect of carbon monoxide, in particular on the effect it has on the brain. Dr. Lewin also tells us of the therapeutic advice given at a later date by the Arabian physician and philosopher, Avicenna (980-1037), concerning paralysis caused by the toxic fumes of carbon monoxide.

Despite the advance of knowledge in the natural sciences in antiquity and the following centuries, one encounters in western European countries in the early Eighteenth Century a certain ignorance, at least concerning carbon monoxide. Many sudden deaths or chronic ailments, which in those days were ascribed to the work of the devil, may have been caused by the effect of carbon monoxide. There is a true story of an incident which took place in 1715 in Jena, Germany, and aroused great public concern as being a work of the devil: one student promised two farmers to share a treasure with them if they would come with him on Christmas Night to a little hut in a vineyard where the treasure was buried. At the stroke of midnight the student was to call the spirits to reveal to him the secret place of the treasure. It was a cold night, and to warm themselves while waiting for the hour of the ghosts, they kindled a wood fire inside the hut. The next day, all three were found dead. And so the story spread, and also the myth that those who call the devil become victims of the master of darkness. And this theory was not believed by the simple people alone, but also by members of the medical profession. The renowned physician Fredrich Hoffman, professor at the nearby University of Halle, felt it necessary to dispel the ignorance expressed by his worthy colleagues by publishing a paper about the case. He remained anonymous at first, denying the intervention of the devil, explaining the cause and effect of carbon monoxide, and demonstrating that "polluted vapors suppress the influx of clean air, and if man or animal has breathed this type of polluted air, he may faint and, if not helped immediately, suffocates for lack of air. Because the sensation is that of strangulation or like drowning in water."

The modern world has come a long way since 1715, but not far enough in regard to the air which surrounds us. Air pollution control engineering in the United States was developed in 1868 and organizations demanding legislation made their voices heard, but it was not until the First International Congress of Labor, held in Washington, D. C., in the fall of 1919, that delegates were asked to call the attention of their respective governments to the steady increase in industrial CO and requested to make investigations leading to its prevention. The rapidly increasing use of the internal combustion engine was mentioned as one source of this toxic gas.

It is recognized today that the motor vehicle is the Nation's greatest single source of carbon monoxide pollution. Eighty-five million motor vehicles were registered in the United States in 1965. From every gallon of fuel burned in the motor vehicle, three pounds of carbon monoxide (plus other pollutants) are emitted into the air.

In March 1966, the Secretary of Health, Education, and Welfare approved new standards, including standards for carbon monoxide, which will be applicable to new motor vehicles and new motor vehicle engines (domestic and imported) beginning with 1968 models.

With the tremendous industrial and technological advances in the United States, we have arrived at an era where the pollution of our environment has become an important issue.

One of the programs of the Division of Air Pollution is evaluation of the current knowledge in regard to carbon monoxide and further research on its biological and environmental effects and to establish criteria for the overall quality of the air in order that we may enjoy the industrial advances of our century, and at the same time safeguard our health and well-being.

We are living in an exciting time indeed. Today, one of man's greatest unsatisfied desires, a desire as old as man himself--the conquest of space--seems at last to be within his reach. However, man is a terrestrial animal and sometimes we tend to ignore this important fact. Man directs his efforts mostly toward the near-impossible--thereby neglecting every-day life and necessities. What our modern man has achieved in modern technology and will still achieve before this century is over is indeed the near-impossible; however, with all his knowhow he is still enslaved by his environment. This he could master, were he only to be mindful of it.

In this connection one can draw an analogy between our wonderful civilization and the golden age of ancient Rome. Then as now it was an era teeming with technology. Roads, aqueducts, and sewers were constructed and many of them are still in use today. The houses of the Roman patricians were fitted with a comfort equaling our Twentieth Century homes. Yet in spite of all their knowledge and achievements, the most elementary sanitary precautions were disregarded. The great mass of refuse and garbage that accumulates in a big city, including the bodies of gladiators and carcasses of animals slaughtered in the arena games, were just dumped into open pits, where they formed what Mumford calls a "cordon malsanitaire." The archaeologist Rodolfo Lanciani found in his excavations about 75 pits or vaults filled with a "uniform mass of black viscid, unctous matter," and the day he discovered the third pit he had to relieve his gang of workmen from time to time, because the "stench from that putrid mound, turned up after a lapse of twenty centuries, was unbearable, even to men inured to every kind of hardship, as were my excavators."

We are appalled. However, despite our ultra-hygienic environment, sterile hospitals, white rooms, air conditioned houses and cars, and all those sanitary and protective modern conveniences we are blessed with, we have not the slightest qualms about pouring daily approximately 250,000 tons of carbon monoxide, in addition to other pollutants, from motor vehicles alone, into the atmosphere. We regard it as a vast boundless dumping place for our aerial garbage.

More facts and figures could be stated. However, these facts and figures should not be our only criteria; what about the esthetics? What about the beauty of nature to enhance our life and our well-being? The beauty of our environment is now obscured by smog; the fresh, crisp air on a clear morning is polluted by the smell of combustion. Will our future generations be just hibernating in air conditioned dwellings and become oblivious to the sense of outdoor beauty? Will life offer nothing but technology and to quote Sarton produce only "technocrats"? For some time to come we will be inhabitants of this planet, dependent for life on the air surrounding us. With all the admiration we have for the great technological achievements, we should be mindful also of the every-day humdrum environment in which we live, and do all we can to make it a healthful and beautiful place in which to live.

A. G. C.

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Lanciani, Rodolfo Amadeo: Ancient Rome in the Light of Recent Discoveries. Eighth Edition. Boston, 1892.

Lewin, Louis: Die Kohlenoxydvergiftung. Ein Handbuch für Mediziner, Techniker, und Unfallrichter. (Carbon Monoxide Poisoning. A Manual for Physicians, Engineers and Accident Investigators.) Julius Springer, Verlag, Berlin, 1920, 370 pp.

Medizinischer Monatsspiegel. Eine Zeitschrift für den Arzt. (Medical Monthly Mirror. A Journal for Physicians.) Heft 12, Dec. 1957.

Mumford, Lewis: The City in History. Its Origins, Its Transformation and Its Prospects. Harcourt Brace and World Inc., 1961, 657 pp.

Restoring the Quality of Our Environment. Report of the Environmental Pollution Panel, President's Science Advisory Committee. The White House, Nov. 1965, 317 pp.

Sarton, George: A Guide to the History of Science. A First Guide for the Study of the History of Science. With Introductory Essays on Science and Tradition. Waltham, Mass., Chronica Botanica, Co., 1952, 316 pp.

INTRODUCTION

Although this annoted bibliography on carbon monoxide includes publications from 1880 to 1966, it represents a selection from the wealth of literature on this subject.

Many sources have been used in preparing this bibliography, including other bibiographies, books, journals, and reviews on the subject. Where an abstract has been adapted from other bibliographic sources, credit is given by adding the abbreviation of the publication, or initials of the abstractor, at the end of that particular abstract. (See Glossary of Abbreviations.)

The bibliography proper is arranged under subjects. Within each subject the abstracts are arranged by first author, or by first significant word in the title, if no author is given. Since many articles contain material on several phases of the subject, an effort has been made to place each abstract under the most pertinent subject. An item number at the upper left of each abstract is used for identification.

In addition to the bibliographic listing of the abstracts, the State, City-County and Inter-State Reports are listed separately, as well as miscellaneous references. These entries are not numbered. The State, City-County and Inter-State Reports are listed alphabetically by geographic name. Some are briefly annotated. "Miscellaneous References" are listed by title.

There is a complete author index, listing all United States authors, but only two authors of foreign publications. The authors are arranged alphabetically listing the number of the corresponding abstract and, in parentheses, the year of publication. Dashes and commas are used to indicate whether the author is the principal, second, third, fourth author, etc. For example:

Larsen, R.I., 851 (1966),
-, 676 (1965), -, -, 909 (1965)

This indicates that Larsen, R.I. is the principal author of item 851, the second of 676, and the third author of item 909.

A Geographic Location Index and Glossary of Abbreviations complete this bibliography.

BIBLIOGRAPHICAL LISTINGS

ANALYSIS

1. Air injection has high potential. Chem. & Eng. News 43:46 (May 31) 1965.

Recent work on air-injection systems shows that method has potential for nearly eliminating, not just reducing, hydrocarbons and possible carbon monoxide from exhausts. Core of the system is a pump that injects air into an auto's exhaust manifold. Du Pont, according Dr. Cantwell, is doing work on ceramics that might be strong enough for manifolds to make air-injection system commercial practicable. Present manifold not durable but do cut hydrocarbon emission to 54 p.p.m. and carbon monoxide to 0.6%. Other tests by General Motors show higher levels but in their opinion, also, good potential exists for the system. - CBK

2. Adams, E.G., and Simmons, N.T.: The determination of carbon monoxide by means of iodine pentoxide. J. Appl. Chem. (London) 1(Suppl. 1): S20-S40, 1951.

Difficulties in the application of iodine pentoxide to the determination of carbon monoxide in mine air, Diesel exhaust gas, coal gas, etc., are reviewed. Re-examination of the problems has shown that they can readily be overcome.

The preparation of pure iodic acid and fully reactive iodine pentoxide is discussed. A trouble-free purifying and drying train, employing solid reagents only, for the removal of interfering gases, is described and the effect of lower paraffinic hydrocarbons is discussed. - Authors' Abst.

3. Allen, T.H., and Root, W.S.: Colorimetric determination of carbon monoxide in air by improved palladium chloride method. J. Biol. Chem. 216:309-317 (Sept.) 1955.

Christman's method of analyzing CO in air by the reduction of Pd Cl_2 has been extremely improved so that it is suitable for use in physiological experiments. With samples of less than 100 ml. it is possible to analyze CO percentages of 94.2, 0.010, and even less. The accuracy and consistency of the method are shown by recovery of 99.6%, with a standard deviation of 2.21%. The lower-most limit of the method, which has not been approached, has to do with the least quantity of Pd Cl_2 that can be accurately measured by spectrophotometry of PdI_2 solutions.- APCA 582

4. Anderson, T., and Dahlstrom, H.: A clinical method for the determination of carbon monoxide in air. Sc. Tools (Stockholm) 5:9-11 (April) 1958.

An objective method for determining the concentration of carbon monoxide in air in the range 1-100 ppm. using indicator tubes according to Shepherd is described. The sample is passed at a constant flow through the indicator tube mounted in the optical path of a Beckman Model-B spectrophotometer and the time required to obtain a certain extinction value is measured. This time is a function of the CO concentration in the sample. The sensitivity of the method is very high and corresponds to an error of the order of 1-6% in the range investigated. In addition, it has several considerable advantages over earlier methods. Once a calibration curve has been obtained, the method is absolute and requires no standard gas mixtures. It is completely independent of the existing lighting conditions as well as of the investigator's color sense. It is easily adapted to different ranges of carbon monoxide concentrations. Finally, a relatively small quantity of sample gas is required even at very low CO concentrations. - APCA 2118

5. Ayer, H.E., and Saltzman, B.E.: Note on interferences by oxides of nitrogen with estimations of carbon monoxide in air by the NBS indicating tubes. Amer. Indust. Hyg. Ass. J. 20:337-339 (Aug.) 1959.

Nitrogen dioxide and nitric oxide interference with carbon monoxide estimations by the NBS indicating tube were investigated. Both oxides were found to interfere seriously, the nitrogen dioxide to a great extent. Nitrogen dioxide interference can be eliminated and nitric oxide intereference considerably reduced by using a U-tube with solid potassium permanganate in the upstream leg and Ascarite in the downstream leg. The U-tube is flushed with the contaminated air, using the rubber bulb, and then connected ahead of the indicating tube. The field determination of carbon monoxide is then made in the usual way. No interference may be expected from concentrations of nitrogen oxides up to 15% of that of carbon monoxide. If an NBS tube estimation without the U-tube does not give a color lighter than one made with the tube, then nitrogen dioxide can be presumed to be within its threshold limit of 5 ppm. The degree of interference eliminated by the tentative method reported here was sufficient for immediate needs. - APCA 2732

6. Beatty, R.L.: Methods for Detecting and Determining Carbon Monoxide. USBM B557 (Rev. of TP582), 1955, 34 pp.

This publication discusses the various methods now used more or less generally for detecting and determining carbon monoxide in air and in other gaseous mixtures, outlining briefly the reactions or principles upon which the methods are based, the range of concentrations that may be determined, and the accuracy of determination. Other methods that are specialized in application or that have not received general use are discussed in less detail. References are given to pertinent original publications that describe the methods in greater detail. Methods for detecting and determining carbon monoxide that have been developed since this publication first was issued by the Bureau of Mines BMTP 582: Methods for the Detection and Determination of Carbon Monoxide, by Berger, L.B., and Schrenk, H.H. - Author's Abst.

7. Berger, L.B., and Schrenk, H.H.: Methods for the Detection and Determination of Carbon Monoxide. U.S. Bureau of Mines Technical Paper #582, 1938, 30 pp.

Carbon monoxide may be formed in any process involving the oxidation or combustion of carbon-containing material, hence it occurs as a product of many industrial and domestic processes. It may be considered a normal product of combustion, as in automobile exhaust gas, or an abnormal product, as in the gases from space heaters. Contamination of the atmosphere with carbon monoxide is hazardous to the health and safety of persons exposed to such atmospheres.

The numerous accidents caused by carbon monoxide have led to a more general appreciation of the hazards created by this gas and have aroused increasing interest in methods for its detection and determination in the atmosphere. Knowledge of these methods should promote health and safety, and they should be applicable to many processes that are studied or controlled by gas analysis.

This publication discusses the various methods now used more or less generally for the detection and determination of carbon monoxide, the range of concentrations that may be determined, and the accuracy of the determination. The reactions or principles upon which the methods are based and the technique of operation are described briefly. References are given to publications that describe the methods in greater detail, but no attempt has been made to compile a complete bibliography. - Authors' Introduction

8. Berger, L.B.: Determination of Carbon Monoxide by Absorption in the Haldane Type of Gas-Analysis Apparatus. Bureau of Mines Rept. Investigations No. 4187, 1947, 6 pp.

A method is described for determining small concentrations (0.2 to 0.5 percent) of carbon monoxide by absorption in a cuprous sulfatebeta naphthol-sulfuric acid reagent, known commercially as "cosorbent." The modifications necessary to adapt a Haldane gas-analysis apparatus for this purpose are illustrated. Experiments with synthetic gaseous mixtures demonstrated an accuracy and precision of better than ± 0.5 percent for CO in concentrations of 0.10 percent or more. Unsaturated hydrocarbons and hydrogen interfere with the results to the same extent that they are soluble in the reagent employed. A comparison of the analyses of several samples by this absorption method and two other methods yielded agreement within ± 0.05 percent between the various methods used. The absorption method is quite rapid and only requires 20 ml. of sample. - BMB 1520

9. Broering, L.C., Jr.: An evaluation of techniques for measuring air-fuel ratio. Presented at the SAE Annual Meeting, Detroit, Jan. 10-14, 1966.

Four methods for determining air-fuel ratio by exhaust analysis are compared. The methods selected for study are all potentially useful with analyses of integrated samples obtained in road tests or exhaust samples generated in the laboratory. A V-8 engine mounted on an engine dynamometer was used to generate exhaust, from which the air-fuel ratios were determined simultaneously by the various methods. The air-fuel ratio of the mixture delivered to the engine was determined by measuring directly the quantities of air and fuel supplied. This value was compared to those obtained by the four exhaust analysis techniques. Comparisons were made during normal operation and during conditions of deliberate cylinder misfire to simulate the most adverse combustion condition encountered on the road. - Author's Abst.

10. Chass, R.L., Luche, R.G., Tow, P.S., and Shaffer, N.R.: Total air pollution emissions in Los Angeles County. J. APCA 10:351-366 (Oct.) 1960.

The Los Angeles County Air Pollution Control District conducts extensive studies of the emissions of air contaminants into the Los Angeles atmosphere. Results of these studies show 1500 tons of hydrocarbons, 60 tons of aldehydes and ketones, 150 tons of other organic gases, 100 tons of aerosols, 700 tons of oxides of nitrogen, 550 tons of sulfur dioxide and 5450 tons of carbon monoxide emitted daily. These emissions are catalogued by source and, where possible, emission factors have also been included. Procedures used by the APCD in obtaining basic data and utilizing these data for preparing estimates are explained. Examples are given of survey letters and questionnaire forms. The value of total air pollution data to an air pollution program is discussed briefly and the APCD scheme of graphically displaying the emission estimates is illustrated. - APCA 2822

11. Cholak, J.: Nature of atmospheric pollution in a number of Indust. Communities. Proceedings of the Second National Air Pollution Symposium, May 5-6, 1952, Pasadena, Calif., pp. 6-15.

This report deals with following atmospheric contaminants, present in atmosphere of certain American communities: suspended matter, carbon dioxide, carbon monoxide, the halogens, sulfur compounds, ammonia, the oxides of nitrogen, and a group of aldehydes. Since determinations of CO, which exists at an approximately uniform level of 0.03% (300 ppm) in the normal atmosphere, are not commonly made, few comparative data are available. Findings are given in a table. The gradual increase in the averages and the ranges of concentration are shown proceeding from rural toward the more industrialized urban areas. Seasonal variations in the concentrations were not pronounced and are not shown. The data for Chicago and Salt Lake City, are in good agreement with those for Cincinnati. -AGC.

12. Cholak, J., Schafer, L.J., and Hoffer, R.F.: Results of a five-year investigation of air pollution in Cincinnati. AMA Arch. Indust. Hyg. & Occupat. Med. 6:314-325 (Oct.) 1952.

Carbon monoxide was determined at selected points in Cincinnati over 24 months during the years 1947-1950. The method of determination is not given in this paper. The ranges of mean concentrations in rural areas was 0-15 ppm, mean less than 5 ppm; in residential areas 0.25 ppm, mean 4 ppm; in industrial and commercial areas 0-55 ppm, mean 9.5 ppm. The mean of all sections was 7.5 ppm. In two downtown locations on December 19 and 20, 1949, the range was 5-50 ppm and the mean 20.2 ppm. One test result of 200 ppm was not included in the foregoing data as it occurred briefly when a bus stopped near the sampling site. -PHS-RG 5676

13. Cholak, J: Measurement of air pollution. A.M.A. Arch. Indust. Hyg. & Occupat. Med. 10:203-209 (Sept.) 1954.

Attempts to detect and measure the constituents of the atmosphere on a comprehensive scale are of rather recent origin. Although many data are available on certain air pollutants, procedures and equipment are lacking for collecting and analyzing these and many other pollutants during adverse weather conditions. Not even a tentative appraisal of the impact of air pollution upon community health can be obtained solely through the determination of the qualitative and quantitative composition of the atmosphere of communities, but it is evident that no satisfactory understanding of the matter can be achieved without fairly comprehensive information of this type. It seems necessary threfore thatthis, probably the simplest aspect of the general problem, should be investigated widely and intensively. -Author's Sum.

14. Cholak, J., Schafer, L.J., and Yeager, D.W.: The concentration of ozone in the atmosphere of certain American cities. J. APCA 5:227-248 (Feb.) 1956.

The determination of oxidant in the atmosphere of 10 Eastern and Midwestern American cities by the method used in the Los Angeles area demonstrates that the concentration of oxidant, as so determined and recorded, varies inversely with the concentration of sulfur dioxide present in the atmosphere. The levels of concentration of oxidant were generally so low as not to lend themselves through quantitatively adequate fluctuations, to correlation with meteorologic variables.

The levels of concentration of carbon monoxide in the atmosphere, so far as this was investigated, appeared to vary with the density of motor traffic. The concentration during the day generally reached its peak during the period of maximum traffic, but on other days it remained at a uniform level (whether high or low) throughout the entire day. The latter fact would seem to indicate that there are highly significant sources of carbon monoxide in the atmosphere which do not depend upon vehicular traffic, or--what is more likely--that the concentration varies with the turbulence of the air at the site. - Authors' Abst. Modified.

14a. Cholak, J., Schafer, L.J., Yeager, D.W., and Younker, W.J.: Gaseous contaminants in the atmosphere. Arch. Indust. Health 15:198-206 (March) 1957.

The concentration of sulfur dioxide in Cincinnati varied with the season. It was lowest during the summer when the combustion of solid fuel was at a minimum. The level of concentration of oxidant as recorded by the potassium iodide recorder varied inversely with the concentration of sulfur dioxide; it was highest in the summer. The oxidant was usually highest during the afternoon and lowest during the night. The pattern was different from that observed in downtown Los Angeles where the maximum concentration was generally reached near the middle of the day. The concentration of the oxidant in Cincinnati ranged between 0.2 and 6 pphm. The concentration of nitrogen dioxide ranged between 0.2 and 9.5 pphm, and was generally highest at night. The lowest concentrations were found when the oxidant was highest. The concentration of carbon monoxide at all periods was very near the limit of detection of the method employed, generally below 1 ppm. The effects of meteorological factors on the fluctuation in the four contaminants should be determined by an extended program of monitoring with continuous recording equipment. More information is needed to establish the relationship between the fluctuations in the concentrations of oxidant and nitrogen dioxide in the air. Continuous records for total nitrate and nitric oxide would be of value in establishing the fate of the nitrogen dioxide in the atmosphere. - Authors' Abst.

15. Chovin, P.: Studies of Atmospheric Pollution in the Department of the Seine, in 1963. Municipal Laboratory Police Headquarters, Paris, France, 1964.

1963 test results for continuing studies in Paris, France, titled "Carbon Monoxide," "Policemen 1963," "Seine Loop," and "Smokeless Zones," are reported. Previous years' results are confirmed. Surface and underground tunnel measurements of CO in air are compared. The CO pollution level in the air went from "considerable" in 1962 to "serious" in 1963, but in the first 9 months of 1964, the situation reversed to that of 1962. The increase in 1963 is ascribed to the number of new roads and concurrent traffic increase. CO levels in blood were examined in a CO-exposed population consisting of industrial employees, auto drivers involved in accidents, and individuals suffering from CO exposure. Tests for "average real risk" of carbon monoxide absorption by individuals indicated that the auto drivers as a group had a much higher level of carbon monoxide in the blood than that of the rest of the population studied, including workers exposed professionally. - CBK (from French)

16. Christman, A.A., Block, W.D., and Schultz, J.: Determination of carbon monoxide in air. Indust. Eng. Chem. (Anal. Edition) 9:153-156 (April 15) 1937.

A comparatively simple procedure requiring very little special apparatus is described for the determination of carbon monoxide in air. The method is based primarily on the fact that palladium chloride is reduced by carbon monoxide and the excess of palladium chloride which is present is determined colorimetrically after addition of potassium iodide. - Authors' Sum.

17. Cier: Detection and measurement of carbon monoxide. Rev. Corps Santé Militaire (Paris) 14:338-352 (Sept.) 1958.

The author reviews and briefly discusses some of the various methods for the detection and measurement of carbon monoxide. These are grouped under the 2 headings of chemical methods and physical methods. The chemical methods are those based on the oxidation of CO (in the presence of metallic oxides; by anhydrous iodine liberating iodine gas; by metallic salts), or the formation of complexes. Physical methods involve either an indirect (by first absorbing the gas) or a direct approach. Several of the latter methods, such as refractometry, interferometry, polarography, or those based on conductibility, are not readily available in small laboratories. A practical method based on infrared spectrography is discussed in some detail. There is appended a bibliography of 52 items. - APCA 2737

18. Ciuhandu, G; Photometric determination of carbon monoxide in the air. Fresenius Zeitschrift für Analytische Chemie 155:321-327, 1957.

A photometric process of CO determination based on gas absorption in an alkaline silver compound solution of the p-sulfonamide-benzoate is discussed in this paper. The silver compound is being reduced to metallic silver which remains in colloidal distribution. The extinction of the silversol is being measured and is proportional, according to working prescriptions, in the area of 0.001-0.5% CO. By wavelenghts below 500 mμ there is a considerable increase in the extinction. For this reason incasurements are made during short periods of light. With a ZEISS - filter S42 the incasurement sensitivity is about doubled. The method of CO determination is described in detail. -Author's abst. translated AGC

19. Clayton, G.D., Cook, W.A., and Frederick, W.G.: A study of the relationship of street level carbon monoxide concentrations to traffic accidents. Amer. Indust. Hyg. Ass. 21:46-54 (Feb.) 1960.

Three locations representative of different traffic situations, and one residential, non-traffic location in Detroit were monitored for CO level using 2 MSA Lira Infra-red Gas Analyzers and one Perkin-Elmer Tri-non Infra-red Gas Analyzer, Model 105. Sampling sites: 1) Central Business District--triangular traffic island, 50 feet to a side, in the middle of busy intersection; 2) Neighborhood Shopping Area--inlet 4 feet above street at curb line; 3) Depressed Highway--inlet 4 feet above street, at curb line; 4) Residential Area--back yard of home. Results: 1) Central Business District--21 weeks sampling. Range, 0-100 ppm; median, 9 ppm. 2) Neighborhood Shopping Area--58 weeks sampling. Range, 0-100 ppm; median, 10 ppm. 3) Depressed Highway--27 weeks sampling. Range, 0-100 ppm; median, 8 ppm. 4) Residentail Area--18 weeks. Range, 0-29 ppm; median, 2 ppm.

CO levels in the driver's breathing zone of passenger automobiles were also measured, using an MSA Type 45411 carbon monoxide indicator. Levels in the automobiles were higher than at curb side, but were judged not physiologically significant. Range, 0-120 ppm; median, 17 ppm. Blood samples were analyzed from 237 persons involved in traffic accidents, (drivers, passengers, and pedestrians). Only 3 had CO-hemoglobin saturation exceeding 10%, the generally accepted threshhold for impairment of driving ability. The conclusion is that ambient CO levels in Detroit are not sufficient to impair driving ability.

19a. Clayton, G.D., Cook, W.A., and Fredrick, W.G.: Carbon Monoxide and Its Relation to Traffic Accidents. Report of Research - U.S. PHS Grant RG 5676 National Sanitation Foundation, Ann Arbor, Michigan (Received Feb. 1964).

Carbon monoxide is a common air pollutant in urban areas. To what extent this gas contributed to traffic accidents was the basis for an extensive study in Detroit, Michigan. Variations in carbon monoxide gas concentration in the atmosphere near streets can be partially explained by changes in meteorological and traffic conditions. A statistical analysis has demonstrated that hourly carbon monoxide concentration can be predicted with sufficient accuracy using as explanatory variables traffic density, temperature inversion, wind speed, and temperature. Variations in the effect of traffic density were found for the several regressions fitted. The smaller positive coefficient at the depressed highway station suggested that because of a more rapid flow of traffic, a larger input of traffic is needed at the margin per unit output of gas. The larger coefficient at the neighborhood shopping and downtown Detroit locations indicated a less significant role for the ground turbulence variable. Large traffic density coefficient were established at the neighborhood shopping area. The significance of the meteorological variables on carbon monoxide concentration levels also varied by sampling location. Although only tentative conclusions may be drawn from the downtown Detroit data, the meteorological impact appears strongest at this station. Whatever dispersive or retentive effect these variables may have at the other two locations, there they appear to be of secondary importance when compared with the ground turbulence created by the more rapid flow of traffic. Investigators state that downtown Detroit, with its congested traffic, tall buildings, and slow traffic movement, has the necessary input to make it a potential air pollution danger area. Investigators further state that it is precisely in this part of the city additional research may well be directed. For the present and immediately succeeding years the current study has demonstrated that ambient carbon monoxide as an air pollutant is not a factor in causation of motor vehicle accidents under urban conditions comparable to those existing during the course of this study. There are 29 tables and 26 figures. - Authors' Sum. Modified-AGC

20. Colucci, J.M., and Begeman, C.R.: The automotive contribution to air-borne polynuclear aromatic hydrocarbons in Detroit. J. APCA 15:113-122 (March) 1965.

The General Motors Research Laboratories and the Sloan-Kettering Institute for Cancer Research are collaborating to determine the contribution by automotive vehicles to the polynuclear aromatic hydrocarbons in city air. Sampling of particulate matter at the rate of 140 M^3/min (5000 cfm) was carried out at two heavily-trafficked sites in Detroit and one suburban site in Warren, Michigan. Carbon monoxide was determined continuously, and particulate matter was analyzed for "tar," polynuclear aromatic hydrocarbons, lead, vanadium, and sulfates. Polynuclear aromatic hydrocarbons in automobile exhaust gas are assumed to be dispersed in air along with carbon monoxide or lead from automobiles. It is further assumed that automobiles are the sole source of carbon monoxide and lead in the atmosphere. Concentrations of carbon monoxide and lead in exhaust gas and in the air are utilized to estimate the percentage of polynuclear aromatic hydrocarbons in the air attributable to automobiles. The mean automobile contributions to benso(a)pyrene in the air, based on lead concentrations, were 18% at a Freeway Interchange, 5% in a downtown commercial area, and 42% in suburban Warren. The average concentrations of benzo(a)pyrene at the sites were 6 $\mu g/10^3 M^3$, 7 $\mu g/10^3 M^3$ and 1 $\mu g/10^3 M^3$, respectively. Mean contributions based on carbon monoxide concentrations were approximately twice the levels based on lead concentrations. Benzo(a)pyrene and benz(a)anthracene in air were not statistically related to carbon monoxide or lead in air, but were higher in winter than in summer, probably because of the higher levels of these materials emitted in space heating combustion in winter. - Authors' Abst.

21. Connolly, J.I., Martinek, M.J., and Aeberly, J.J.: The carbon monoxide hazard in city streets. Amer. J. Pub. Health 18:1375-1383, 1928.

An investigation was carried on in Chicago wherein 690 street-air samples were collected and tested for carbon monoxide content. The distribution of samples by concentration brought out three type of streets: Residential and industrial; traffic and carline; and motorcar boulevards. The boulevards had approximately twice the air pollution of the traffic streets, and four times that of the residential and industrial streets. A definite correlation was found between the number of motorcars passing at the time the sample were collected and the amounts of carbon monoxide found to be present. When no car was passing for 5 minutes the carbon monoxide was as low as 0.1 part per 10,000. Two peaks occurred daily, coinciding with the morning and evening rush hours. The concentration for such times is enough to menace the health of anyone exposed for several hours to such an atmosphere, particularly if his activities call for deep and rapid breathing. Further studies are required to determine the concentration of carbon monoxide in the blood of such persons, and the presences of any injury to health. It is recommended that idling of motors on street should be restricted to a minimum, and it is pointed out that the whole question is one of increasing importance.- BMB 398

22. Del Vecchio, V., D'Arca, S., and Talenti, M.: Carbon monoxide intoxication and carbon monoxide in the atmosphere in Rome. Nuovi Ann. d'Igiene e Microbiol. 7:81-102, 1956.

The 1st part of this article discusses the origin of CO contamination of the atmosphere of towns, the pathogenesis of CO poisoning, the relation between symptoms and concentrations of carboxyhemoglobin (COHb) and the atmospheric concentrations estimated by investigators in various cities of the world. The chief source of CO in urban surroundings is the presence of escape gases from motor vehicles, estimated in proportions varying from 3-14%, depending on the nature of the fuel, the cylinder performance, traffic congestion, confined spaces, etc. The affinity of CO for hemoglobin is 210 times greater than that of O_2, so that only small amounts of CO are necessary to immobilize significant amounts of hemogolbin with resulting decrease of O_2 transport by red blood corpuscles, leading to anoxemia and asphyxia. CO also binds respiratory ferments, interfering seriously with the oxidation-reduction mechanism, thus adding to its asphyxiant action the inhibition of respiratory tissue activation. Its toxic action is related essentially to the concentration of COHb. A table is given showing the correlation between the concentration of CO and O_2 in inspired air, the duration of exposure and the condition of pulmonary ventilation. Thus, for example, if a man with pulmonary ventilation of 9.51./min. is exposed for 2 hours to 0.03% CO, the % of COHb in the blood reaches 15.6; in 3 hours it reaches 20. The coefficient of COHb/Hb indicates the % of Hb effectively transformed into COHb. In man, the lethal index is 0.66, i.e., death takes place when 2/3 of Hb is fixed. In a normal person at rest, 10% of COHb causes no symptoms, 20% slight headache, 32% headache, irritability and vertigo, 50% mental confusion and syncope, 66% unconsciousness and death, if prolonged. In the 2nd part of the article, the authors describe their own investigation of the CO concentration in the air of Rome from Nov. 1954-Oct. 1955, in various zones, at different times and in varying weather conditions, using Drager's apparatus with I_2O_5 as the colorimetric agent. The maximum concentration (0.015%) occurred in the Traforo del Quirinale in cloudy weather during intense traffic. While this is not likely to cause appreciable intoxication in the adult pursuing his ordinary avocations, individuals doing heavy work for 1-1/2 hours may experience initial symptoms, and in those spending a great part of their life in places where CO is constantly present may undergo some disturbance which may be aggravated by atmospheric contaminants. - Kett.

23. Del Vecchio, V.: Determination of carbon monoxide in the air. Minerva med. (Turin) 49:1028-1048 (March 21) 1958.

Carbon monoxide is discussed as to nomenclature, physiochemical properties, toxicity, tolerable concentrations, and methods of measuring its concentration in the air. Some of the semi-analytical methods of measurement in the air are listed and discussed in detail. They fall into the 3 main groupings of: titrimetric, using pentose oxide; photometric, using palladium chloride; and a method measuring the level of carboxyhemoglobin, or COHb, in the blood. Some of the continuously or semi-continuously measuring methods are also discussed. Many schematic drawings and photographs of the testing equipment are included in the text, together with graphs showing the toxicity of CO as a function of concentration and of the period of time of exposure; the rate of saturation of hemoglobin with various concentrations of CO in the air; and the percentage of carboxyhemoglobin in the blood correlated with percentage of CO in the air, the period of exposure, and the activity of the subject. - APCA 2823

24. Demidov, A.V., and Mokhov, L.A.: Rapid Methods for the Determination of Harmful Gases and Vapors in the Air. Medgiz, Moscow, 1962. In: Levine, B.S. (translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 10, 1964, 108 pp., CFSTI-TT-64-11767, U.S. Dept. of Commerce, Springfield, Va.

Following a short discussion of the bases of the rapid methods and of suggestions on the collecting of samples, information is given in considerable detail on various inorganic substances and on various organic substances in the air. The inorganic substances are: carbon monoxide (CO), nitrogen oxides, hydrogen peroxide (H_2O_2), ozone (O_3), chlorine (Cl_2), hydrogen chloride (HCl), hydrogen sulfide (H_2S), carbon bisulfide (CS_2), ammonia and aliphatic amines, arsenic hydride or arsine (AsH_3), antimonous hydride (SbH_3), fluorine (F_2), sulfur dioxide (sulfurous anhydride, or sulfur dioxide, SO_2), mercury vapor (Hg), hydrocyanic acid (HCN), nickel tetracarbonyl [$(Ni(CO)_2$], carbon dioxide (CO_2). The organic substances are: formaldehyde (HCOH), ethyl alcohol vapor (C_2H_5OH), liquid fuel vapor, phosgene ($COCl_2$) acetylene (C_2H_2), benzene vapor, ethylene oxide (C_2H_4O), aniline ($C_6H_5NH_2$), acetone (CH_3--CO--CH_3). There are six appendices which give such information as volume, percent, and weight conversion formulas and tables; tables of ready calculated factors; and specific gravity equivalent concentrations for some acids. - APCA 7082

25. Development of a Mathematical Model for Predicting Carbon Monoxide in an Urban Area. Report of research on carbon monoxide and its relation to traffic accidents. National Sanitation Foundation, Ann Arbor, Mich. (received Feb. 17, 1964), U.S. PHS R.G. 5678.

Carbon monoxide is a common air pollutant in urban areas. A major objective of this study was the statistical estimation of the parameters of those variables which influence atmospheric carbon monoxide concentration.

It is known that variations in carbon monoxide gas concentration in the atmosphere near streets can be partially explained by changes in meteorological and traffic conditions. Although traffic density is the major contribution variable, meteorological factors such as wind speed, temperature, temperature inversion, and wind direction must be considered because of their relentive and dispersive effect on gases. However, no one, to the knowledge of the investigators, has attempted statistically to assess the quantitative importance of these variables, or to test the efficacy of a postulated mathematical model in explaining carbon monoxide variability in the atmosphere.

A statistical experiment was designed and executed in the city of Detroit. Statistical analysis has demonstrated that hourly carbon monoxide concentration can be predicted with sufficient accuracy using as explanatory variables traffic density, temperature inversion, wind speed, and temperature. There is evidence to indicate that the impact of these variables differs by sampling location. The significance of the meteorological variables on carbon monoxide concentration levels also varies by sampling location.

This study illustrates the complementarity and importance of careful experimental design and proper statistical analysis. There are 29 tables, 26 figures and an annotated bibliography.
AGC

26. Dubois, L., and Monkman, J.L.: The analysis of carbon monoxide in urban air at the PPM level and the normal carbon monoxide value. J. APCA 16:135-139 (March) 1966.

Present methods for the determination of carbon monoxide are discussed including indicator tubes, the iodine pentoxide reaction and measurement by gas chromatography. In the gas chromatographic method an air sample is separated on a gas-solid chromatographic column and the separated CO is converted to methane by hydrogenation at elevated temperature. The separated CO, in the form of methane, is passed into a hydrogen flame detector and measured. The conversion from CO to methane allows the use of a sensitive ionization detector in place of the thermal conductivity cell which is insufficiently sensitive for the measurement of trace amounts of CO. The optimum operating conditions are discussed. It is possible to determine 1 ppm. CO in air. The iodine pentoxide reaction with CO has been combined with electrometric measurement. The iodine liberated is passed into a Ditte cell and the current generated is measured by an electrometer-recorder combination. This method is continuously direct reading with a permanent record. It is suitable for the continuous routine analysis of 1 ppm. CO. - Authors' Abst.

27. Drawin, H.W.: Mass spectrometric analysis of auto exhaust and air pollutants. Automobiltechnische Zeitung 62:104-109, 1960.

With an electric or magnetic field arrangement mass spectrometry permits the separation of ions in space and time, according to their ratio of mass to electric charge. The substance to be investigated has to be put into the ion sources in the form of gas or vapor. The ion streams, in proportion with the concentrations of the components, are measured by oscillagraphy. When investigating auto exhaust it can be directed through a pipe line to the mass spectrometer. It is to be observed that the condensating components (approximately 15%) are not lost to the analysis because this would falsify the results. The usual instruments are to be equipped with reheat devices up to 180°C, auxiliary attachments even up to 350°C. By other methods of sampling an evacuated glass flask can be used. Mass spectrometry is also suitable for the analysis of other air pollutants. - AGC

28. Dunlap, R.: Carbon monoxide the silent killer. Today's Health (Nov.) 1961, pp. 26-27, 67-68, and 71-72.

Every year motor vehicles pour out 169,600,000,000 pounds of CO into the air of American cities. The share of each urban dweller amounts to some 30 pounds of the deadly gas every 24 hrs. By 1970 an expected 100 million vehicles will be traveling some trillion miles a year and the possible environmental danger from CO will have to be controlled. CO has a remarkable affinity for red blood cells. It is absorbed by them 250 times as fast as oxygen. The gas unites with the hemoglobin and keeps it from carrying oxygen to the tissues. This means that even a seemingly inconsequential .02 percent CO can be lethal. Tobacco smoking also increases the level of CO in the blood. Police files show that every year 600 lives are lost due to carbon monoxide in the United States. It is also assumed that this colorless, tasteless, nonirritating, and odorless poison gas is a contributing factor to a high percentage of approximately 180,000 highway accidents caused annually by drivers who black out or fall asleep at the wheel. Concern is expressed about the level of CO poisoning that may be encountered by a motorist smoking a cigarette. Studies conducted by the U.S. Public Health Service's Division of Air Pollution and such by other authorities are discussed to alert the public to the danger of carbon monoxide. -AGC

29. **Edell, G.M.: Determination of small amounts of carbon monoxide in air. (Abstract of Thesis, Syracuse Univ.) Indust. Eng. Chem. 20: 275 (March) 1928.**

It seemed desirable to test air for smaller concentrations of carbon monoxide than had previously been reported. Oxidation by means of iodine pentoxide was selected as the most accurate method in use. Several test analyses were made from each of four different concentrations of carbon monoxide in air, using an apparatus modeled after Graham's portable type with the bromine tube omitted. One-liter samples of the two more concentrated mixtures and 3-liter samples of the dilute mixtures were used.

It was found that only the purest iodine pentoxide should be used. Even then there was a constant, though small, liberation of iodine when pure air was drawn through the tube; the rate of decomposition, however, was nearly uniform. It had to be determined and corrections made in computing the results of the analyses. One tube filled with an inferior grade of iodine pentoxide gave untrustworthy results due to a high and uneven rate of decomposition. Water displacement of the gas sample from the reservoir and sampling bulb gave results fully as accurate as vacuum displacement.

Analytical Results

No. of Determinations	Carbon Monoxide		Deviation of Determined Percentages from Computed		
	Computed Per Cent	Determined Per Cent	Average Per Cent	Maximum Per Cent	Minimum Per Cent
6	0.0575	0.0599	+0.0024	+0.0031	+0.0010
4	0.0094	0.0109	+0.0015	+0.0023	+0.0007
5	0.0018	0.0027	+0.0009	+0.0020	+0.0001
7	0.0008	0.0011	+0.0003	+0.0008	+0.0001

The excellent checks obtained on the work of other investigators and the accuracy of determinations on still more dilute concentrations mark the method as one having greater refinement than is generally known, and one whose limit of usefulness has not yet been determined. - Author's Abst.

3 Effenberger, E.: Carbon monoxide and its importance in hygiene. Med. Meteorolog. Hefte No. 12, 1957, pp. 128.

Author discusses in this reference work, besides general data, the problem of carbon monoxide with special consideration of the quantitative method of analysis of atmospheric and industrial air and in the blood. Small amounts of CO in the air are being generally analysed by the J_2O_5 method. According to the method by Fischingen, with minor changes by the author, which is described, it is possible to determine 0.001 Vol.-% of CO. Exact determination of CO quantities below 0.001 Vol.-% are still very difficult to obtain. The most sensitive methods at this time, the iodine and the COHb methods, are also only 7 to 10% accurate. The method for the determination of CO in the blood by Wolff is described and considered by the author to be the most simple and a more reliable procedure than the standard salt solution method. It also has the advantage that the color comparison can be performed independently of wave length of light and also of the color of serum. The accuracy of measurement increased to 3-5%. An extensive bibliography completes this volume. - AGC

31. Evans, R.N., and Davenport, J.E.: Analysis of combustibles in flue gas. Indust. Eng. Chem. (Anal. Ed.) 7:174-178 (May 15) 1935.

A laboratory procedure for flue-gas analysis, designed to estimate the loss due to incomplete combustion, is described, including a comparison of the results of field and laboratory procedures of flue-gas analysis from a recent efficiency test on a modern steam-generating unit. A laboratory apparatus which, employing a synthetic flue gas, is capable of measuring this loss directly is also described. - Authors' Abst.

32. Evreux, R.: Green spaces in Rouen. Current status and prospects. Rev. Hyg. Med. Soc. (Paris) 11:243-248 (April-May) 1963.

A study was made of the green spaces of Rouen and its suburbs. In this area the demographic growth is very high, the economic activity intense, and the atmospheric pollution sometimes reaches an alarming rate. The levels of carbon monoxide in the atmosphere of the arterial streets in the center of the city are similar to those of Paris. The levels of dust, strong acids, and fumes are also high, with conditions being much more severe during the winter. In 1939 the green spaces represented only 1/147 of the total area of Rouen and its suburbs. Big improvements have been made during recent years but the area of the planted space should be doubled if the needs of the town are to be completely satisfied. Different plans have been proposed to accomplish this. - APCA 5732

33. Farre-Rius, F., and Guiochon, G.: Rapid analysis by gas phase chromatography. Separation of a mixture of oxygen, nitrogen, methane, and carbon monoxide. J. Chromatog. (Amsterdam) 13:382-390 (Feb.) 1964.

By careful preparation of molecular sieve 5 A powder, it is possible to obtain much more efficient and permeable columns than were previously available. With such columns a mixture of O_2, N_2, CH_4, and CO can be resolved in less than 15 seconds. - APCA 6366

34. Fassina, L: Fighting the toxic gases of the atmosphere. Chim. et Ind. (Paris) 84:529-531 (Oct.) 1960.

An attempt was made to perfect a chemical catalytic system for the oxidation of toxic carbon monoxide with the resulting formation of the more-or-less harmless compound, carbon dioxide. This was done during the combustion of petrol or gas-oil and air vapors in the cylinders of the engines of operating vehicles. The device employed the use of MnO_2, to form, in the presence of moisture, the compound $Mn(OH)_2O$. This latter form combines with the CO to produce CO_2 and the unstable compound $Mn(OH)_2$, which spontaneously absorbs oxygen from the air and again forms $Mn(OH)_2O$. - APCA 3958

35. Field, F., and McGuire, J.K.: The need for more meaningful meteorological and air quality observations for mortality and morbidity studies. In: Air Over Cities. Symposium, SEC TR A62-5, USPHS, Cincinnati, Ohio, 1962, CFSTI PB-167 552, pp. 277-290.

Author expresses in this paper the need for more knowledge on the interaction between pollutants in the atmosphere and between pollutants and weather elements. Observational and experimental evidence indicates that the toxic effect of CO, a pollutant, is enhanced by higher temperature, a meteorological element. In order to study more specific forms of illness, further investigation is needed to ascertain the role played by weather in transforming or altering pollutants in the photochemical reactions, in the absorption of gases and vapors on particulate material, and in catalytic oxidation and other chemical and physical changes. - AGC

36. Florentin, D.: On the composition of the air in the streets of Paris. Compt. rend., Acad. Sc. 185:1538-1541, 1928.

The observations by Florentin relate to the presence of CO and CO_2. The former was estimated by the "blood method" described by himself and Vandenberghe. The air in those streets where there is much motor traffic shows slight increases in CO_2 content and notable increases of CO content; the amount depends upon atmospheric conditions, an increase from less than 0.01 liter per cubic meter up to as much as 0.045 liter in still weather being observed at times. The increase is greatest at ground level and does not extend to the third floor (troisieme etage). Air for ventilation systems should be drawn from this level. The air in the suburbs is much less polluted than that in the center of Paris. A table shows the result of 27 analyses. - BMB 395

37. Flynn, N.E., and Crouse, W.R.: Carbon monoxide emissions in the Bay Area - 1963. Bay Area APCD, San Francisco, Calif., 18 pp.

Total emissions of carbon monoxide (CO) in the Bay Area Air Pollution Control District for 1963 are estimated at 6500 tons per day. Table 1 contains a summation of emissions of carbon monoxide by general source categories.

Transportation is the major category of carbon monoxide emissions at 4960 tons per day and accounts for 76% of all carbon monoxide emissions. Incineration comprises the largest stationary sources of carbon monoxide emissions at 660 tons per day or 43% of stationary sources. Petroleum refinery operations contribute 410 tons per day, mainly from one fluid catalytic cracker. Agricultural burning is estimated at 470 tons per day.

Average concentration levels of carbon monoxide in the Bay Area range from 2 to 15 ppm (1963) with peaks as high as 49 ppm recorded (1958). The trend in carbon monoxide emissions has been increasing in Los Angeles at the rate of approximately 1 ppm per year. - Authors' Sum.

38. Georgii, H. W., and Weber, E.: Investigation of carbon monoxide emission in a large city. Internat. J. Air & Water Poll. 6:179-195 (May-Aug.) 1962.

This paper discusses continuous records of the carbon monoxide concentration of the air gained at different sampling stations with different traffic intensity in the city of Frankfurt, Ger. The method applied for these measurements was nondispersive ultrared-spectroscopy. The diurnal trend of the CO concentration is mainly influenced by the fluctuation of the traffic during the day. The absolute CO values found are primarily determined by wind velocity, wind direction, and traffic density. The results show that a wind velocity of 3 m./s. or more lead to an efficient dispersion of the automobile exhaust gases within the streets. The investigations show that the automobiles are the only important source of CO in the city, and they are supplemented by measurements in 1 of the recently constructed parking garages and finally deal with preliminary results of the vertical distribution of CO above the streets. - APCA 4893.

39. Giuliani, V., and Belli, R.: Carbon monoxide. Presence in the air of cities and the possibility of poisoning. Folia Med. (Naples) 38:238-248, 1955.

The carbon monoxide in the air of streets, squares, tunnels, and places with heavy traffic, in industrial zones, and in the periphery of Naples was studied. Toxic concentrations were not observed. Persons exposed occupationally for many hours to the highest concentrations showed a carbon monoxide content in the blood within physiological limits and no case of poisoning is on record. - APCA 701

40. Goldsmith, J.R.: Recurrent carbon monoxide exposure. Presented at the Western Indust. Hyg. Conf., San Francisco, Calif., Oct. 7, 1960.

Field investigations, methods applied, and some preliminary results are presented in this paper. Means to introduce a very rapid, simple, and sensitive way of studying CO exposures were established. Using this method, values in equilibrated expired air greater than ten parts per million more than ambient should be considered as evidence of some carbon monoxide source, either occupational, from inhalation of cigarette smoke, from community air pollution, or from hemoglobin breakdown. The use of this test procedure for screening purposes should facilitate the study of recurrent carbon monoxide exposure. - Author's Sum.

41. Goldsmith, J.R.: Some epidemiological problems of community carbon monoxide exposures. Presented at the Air Pollution Research Conference, Los Angeles, Calif., Dec. 4-7, 1961.

The agent, carbon monoxide, was shown to fluctuate over time and place. This is a major factor in effects of exposures of human populations.

The patterns of population exposure must include the exposure of cigarette smokers, of those subjected to community air pollution, those with exposures to motor vehicle exhaust during commuting, and those with occupational exposure to carbon monoxide. A reasonable division of the population in a community was shown to consist of six different categories. Another important population variable consists of those usually sensitive to impaired oxygen transport because of age or medical status.

The mechanism of action is predominantly the impairment of the oxygen transport function of the blood. Other possible mechanisms were discussed.

A mathematical approach for predicting the time course of carboxyhemoglobin, given the temporal fluctuation of carbon monoxide, was derived. These mathematical expressions required some simplifying assumptions. The expressions were used to develop a computer program, and with a simulated set of sinusoidal exposure data, the expected carboxyhemoglobin was calculated, using a method of interative integration.

The possible synergistic effect of other pollutants was reviewed. - Author's Sum.

42. Goldsmith, J.R.: Effects of air pollution on man. Connecticut Med. 27:455-464 (Aug.) 1963.

Community air pollution has been lethal in the disasters of Donora and London and possibly in the New York metropolitan area. Community air pollution is capable of causing acute illness and interference with important bodily function. In addition to its obvious irritating effects, some pollutants such as carbon monoxide produce a subtle impairment of the body's reserve for the transmission of oxygen to the living cell. Community air pollution is suspected as one of the causes of chronic lung disease and lung cancer. So far in the United States it has not been proven to produce these chronic conditions, but it has been shown to do so in England. Community air pollution can be very irritating, can interfere with visibility and produce property damage.

Medical judgment has much to do with the control of air pollution and the prevention of further pollution. - Author's Sum.

43. Goldsmith, J.R., Terzaghi, J., and Hackney, J.D.: Evaluation of fluctuating carbon monoxide exposures. Arch of Environ. Health 7:647-663 (Dec.) 1963.

The patterns of population exposure must include exposure of cigarette smokers, of those subjected to community air pollution, those with exposures to motor vehicle exhaust during commuting, and those with occupational exposure to carbon monoxide. Combinations of these exposures were reduced to 6 typical daily routines which approximated the exposures usually encountered by the population. Estimated exposure of automobile commuter is about 35 ppm, twice normal downtown peak, for duration of trip. Estimated exposure of cigarette smoker is 475 ppm for 6 minutes smoking time per cigarette. - LEPS

44. Goldsmith, J.R.: Uses of medical and epidemiological research in the control and prevention of air pollution. Proc. Royal Soc. Med. 57(Part 2):1034-1040 (Oct.) 1964.

Control by local agencies of visible smoke, odor, and soiling is usually carried out without specific reference to medical or epidemiological research. Systematic atmospheric monitoring usually raises questions about the effects on health of exposure to specific pollutants. While medical and epidemiological data from exposures to sources other than community air pollution may provide specific answers, quantitative relationships cannot usually be derived. Medical and epidemiological research is needed to assess the effects of air pollution on health. While the questions may originally be asked in terms of mortality and morbidity rates, the most valid answers are likely to be in terms of sensory irritation, interference with function, or impairment of visibility. With such information, valid air quality criteria and standards may be defined and used as a basis for regulating the emission of existing pollutants and for planning. In California, air quality standards for oxidant and for carbon monoxide have been used as a basis for control of motor vehicle emissions. Air conservation is a recent concept which is partly dependent on medical and epidemiological research. It emphasizes the need to apply existing knowledge to planning for urban land use, transportation, industrial development and use of fuel and power so that air pollution may be prevented. Epidemiological studies of the chronic effects of air pollution in the United States have been more complicated than in the United Kingdom because of population mobility and changing patterns of exposure to pollution. Estimations of individual exposure to carbon monoxide are now practical and investigations on other pollutants are being undertaken. Many of these problems are reflected in the differing points of view concerning use of sulphur-containing fuels for thermal power generating stations in Los Angeles. Recent pollution in Los Angeles has not been shown to have long-term effects; if such effects were seen they would represent a serious failure to use available medical and epidemiological information to protect the public health. - APCA 64-290

45. Haldane, J.: A method of detecting and estimating carbonic oxide in air. J. Physiol. 18:463-469, 1895.

In view of the very poisonous nature of carbonic oxide, and the comparative frequency with which cases of poisoning by this gas occur, much attention has been given to its detection and estimation. No satisfactory method has hitherto been described, however, for determining very small, but still more or less poisonous, percentages of carbonic oxide in air. There is special difficulty when, as almost always happens, marsh-gas or other hydrocarbons are present along with the carbonic oxide.

The method described in this paper is very simple, and depends on the fact that when a haemoglobin solution is well shaken with air containing carbonic oxide the proportion of the haemoglobin, which finally combines with the carbonic oxide, varies with the percentages of carbonic oxide present in the air. By determining colorimetrically the proportion of the haemoglobin which has combined with the carbonic oxide it is thus possible to infer the percentage of carbonic oxide present in the air.

46. Hamming, W.J., MacPhee, R.D., and Taylor, J.R.: Contaminant concentrations in the atmosphere of Los Angeles County. J. APCA 10:7-16 (Feb.) 1960.

The carbon monoxide concentrations are recorded by means of nondispersing infrared analyzers. Monthly average values plotted for the years 1955 through 1958 showed 3 to 12 ppm as the Basin averages and 4 to 13 ppm for downtown sampling stations. The trend was from an average of 5 ppm in 1955 to 8 ppm for the first half of 1958 for the Basin averages and 6 ppm to 9 ppm for this time range of downtown stations. A graph of diurnal variations in the Basin average for December 1957 showed a range of 6 ppm to 14 ppm. - PHS-RG 5676 (APCA 3416)

47. Hechter, H.H., and Goldsmith, J.R.: Air pollution and daily mortality. Amer. J. Med. Sci. 241:581-588 (May) 1961.

Analysis has been made of the relationship between various environmental factors and daily cardiac and respiratory deaths in Los Angeles County from 1956 to 1958. It was found that the variables, when studied over time, exhibited a distinct seasonal pattern plus some irregular oscillations. The seasonal component from each series was isolated and removed by the techniques of harmonic analysis. A correlation analysis, adjusting for the autocorrelation remaining in the residuals, indicated that changes in the daily air pollution level, as measured by the oxidant and carbon monoxide concentration, exerted no detectable influence upon the day-to-day mortality pattern. Carbon monoxide levels were found to range from about 7 to 22 ppm. and oxidant from 4 to 21 pphm. It is emphasized that these findings, which deal only with the acute terminal response of man to variations in the daily air pollution level, do not mitigate the importance of air pollution as a possible menace to the health and well-being of man. - APCA 3847

48. Heller, A.N., and Walters, D.F.: Impact of changing patterns of energy use on community air quality. J. APCA 15:423-428 (Sept.) 1965.

The air quality of an urban area depends to a great extent upon the quantity and type of fuel consumed. Thus, a marked change in energy demand from 1960 to 2000 A.D. will affect the air quality of all of our urban centers. Interwoven with this potential effect is the anticipated influence of the change in type and quality of fuels, e.g., nuclear fuels, high sulfur coals, and a major modification in energy derived motive power, i.e., fuel cells, and the subsequent depletion of natural gas as an energy raw material. The current trend is to greater urban population densities, and it is estimated that by the year 2000 A.D., 85 percent of America's population will live on only 10 percent of the land mass. To assess the potential impact of the energy demands for the next half century on air quality, particularly of America's urban centers, a review of current practices of combustion of coal, petroleum, and natural gas, and the potential effect on community air quality will be developed. To meet the impact of the interrelated changing patterns of population growth, urban developments, energy requirements and available sources, research needs on both a short and long term basis will be explored. - Authors' Abst.

49. Hettche, H.O.: Comparing views on the burden of soot and carbon compounds in the air of the Federal Republic and other countries. Staub 23:136-140 (March) 1963.

Hydrocarbons and carbon monoxide at present hardly represent a hazard if small groups, such as for example, the neighbours of treatment plants or motor drivers working continuously in large towns, are ignored. The situation is different with respect to the burden placed on large sections of the population by soot and its two adsorbates - sulphuric acid and benzpyrene. In larger towns, therefore, an attempt must be made to employ only low-soot combustion of low-sulphur fuel. (English Summary)

50. Hislop, H.J.: The air we breathe. J. Amer. Physical Therapy Ass. 44:970 (Nov.) 1964.

The air we breathe is being constantly polluted by automobile exhaust, wastes from industrial plants, smoke, and more recently by contaminants from modern weaponry. Air pollution is affecting not only human health but animal and plant existence as well. At a recent forum of the National Health Council it was clearly pointed out that the rapid pollution growth and the increase of urban living has created much of the problem. Two-thirds of the population of the U.S.A. will live in 185 metropolitan areas by 1975. It has been pointed out that the rise in mortality from chronic obstructive ventilatory disease has come much more rapidly than the mortality from carcinoma of the lung. Correlation of

this fact with air pollution will probably be forthcoming. Other facts that have emerged from numerous investigations raise many questions. The increase in air pollution presents a real as well as a potential hazard to life and property. As in other areas of public health, this problem calls for awareness of the individual citizen and guidance by responsible and informed leaders. The physical therapist can serve his community by becoming informed of the local problem, assisting the local health authorities to enforce local remedies, and by demanding action from lethargic governments. Most important, perhaps, is to ensure that adequate public policies on the problem of air pollution are developed. - APCA 64-187

51. Hottel, H.C., Williams, G.C., Nerheim, N.M., and Schneider, G.R.: Kinetic studies in stirred reactors: Combustion of carbon monoxide and propane. Tenth Internat. Symposium on Combustion at Cambridge, England, Aug. 1964. The Combustion Inst., Pittsburgh, Pa., 1488 pp., 1965, pp. 111-121.

The burning rates of carbon monoxide and of propane premixed with oxygen, nitrogen, and water vapor in various proportions were measured over ranges of equivalence ratios and pressures. Burning rates were determined from metered flow rates and analysis of reactor products. The burning rate of carbon monoxide g moles/ml (sec) can be expressed as

$$\dot{N}_{CO_2} = 12 \times 10^{10} \exp(-16{,}000/RT) f_{O_2}^{0.3} f_{CO} f_{H_2O}^{0.5} (P/RT)^{1.8}$$

(T in °K, P in atm, f = mole fraction in reactor); that of propane as

$$\dot{N}_{CO_2} = 2.9 \times 10^{10} \exp(-15{,}000/RT) f_{O_2}^{0.35} f_{CO} f_{H_2O}^{0.4} (P/RT)^{1.75}.$$

A kinetic mechanism is proposed which fits the data for CO with rate constants consistent with literature values. It calls for the rate-limiting step

$$CO + OH \rightarrow CO_2 + H,$$

equilibrium for the following reactions:

$$OH + H_2 = H_2C + H$$

$$H + O_2 = OH + O$$

$$O + H_2 = OH + H$$

and a three-body chain terminating step.

The mechanism proposed for propane combustion involves in addition the very fast reaction of propane to CO and H_2O at the expense of OH, O, and H. - Authors' Abst.

52. **The investigation of atmospheric pollution. Depart. of Scientific and Industrial Res. Fuel Res. London, 1957.**

This publication has been prepared at the Fuel Research Station to assist those who are interested in the measurement of atmospheric

pollution. It describes the investigation of atmospheric pollution, a scheme in which local authorities, Government Departments, industrial organizations, and others, co-operate for the study of pollution and its prevention. It also contains an account of the methods recommended for making systematic measurements of pollution, consistent with a scientific interpretation of the results. - Authors' Sum.

53. Jacobs, M.B., and Greenburg, L.: Air pollution sources. Air Condit. Heat. & Vent. 52:140-142 (Nov.) 1955.

The results of a 2-year study on air pollution in New York City was given in Minneopolis, at the National Meeting of the American Chemical Society. Although soot has decreased, more domestic incinerators are being used. An increase in consumption of fuel oil and wider use of vehicles powered by gasoline and diesel fuel indicated that more pollutants were being put into the atmosphere as exhaust gases. - APCA 743

54. Jacobs, M.B., Braverman, M.M., and Hochheiser, S.: Continuous determination of carbon monoxide and hydrocarbons in air by a modified infrared analyzer. J. APCA 9:110-114 (Aug.) 1959.

By increase of length of the sample tube and by increase of the pressure o-sampling of the Lira-type infrared analyzer, the sensitivity of this instrument was increased sufficiently so that it could be used for the direct measurement of carbon monoxide in the ranges of 0 to 20 ppm and 0 to 50 ppm and of hydrocarbons such as hexane in the ranges of 0 to 5 ppm and 0 to 10 ppm. The elimination of the interference of water vapor attributable to its absorption in the infrared by saturating the air stream with water vapor adjusting the controls has made the instrument suitable for continuous determination of air contaminants in the ppm range. - Authors' Sum.

55. Jeney, E., Szendrey, S., and David, E.: Examination of air pollution with microbiological methods, the accelerative effect of CO on fermentation. Its influence on Pasteur's reaction. Egeszsegtudomany (Budapest) 3:44-58, 1959.

The effects of SO_2, KCN, and CO on the alcoholic fermentation caused by bakers' yeast (S. cerevisiae) in a glucose medium were studied. The effects were mainly compared by measurement of the CO_2 production. Sulfur dioxide and KCN reduced the production of gas in direct relation to their respective amounts. Carbon monoxide caused an acceleration of the fermentation; therefore, this method for the demonstration of CO can be used only when no other impurities are present in the air. The method may be used for demonstrating SO_2, KCN, and other impurities in the air if the CO is removed from the rinsing fluid in the impurities in the impinger by physical means. The method can be of value for the demonstration of impurities in the air, especially those of unknown origin. The results of the examinations were supported by measurement of the "fermentation energy" by Meissel's method, using fermentation experiments with greater amounts of glucose in test tubes. The amount of gas generated was measured with eudiometers; the amount of heat developed was measured with microcalorimetric methods. After recognizing the accelerative effect of CO, the authors consider the question of "endogenous" or "essential" carboxaemia on the basis of studies in the literature. - APCA 3342

56. Jones, G.W., Yant, W.P., and Berger, L.B.: Carbon-Monoxide Hazards from Tobacco Smoke. USBM, No. 2539 (Oct.) 1923, 6 pp.

The Bureau of Mines is interested in the general question of carbon-monoxide hazards from tobacco smoke, mainly with regard to mine ventilation. In non-gaseous mines, especially metal mines, the question arises, whether, if groups of miners are permitted to smoke while working at unventilated faces or entries, would the accumulation of tobacco smoke in these places create any additional hazards due to carbon-monoxide poisoning. The results should, in addition, be of general interest in connection with ventilation of building and inclosed places where people may be assembled and smoking is permitted. The investigation described in this report was made with the above idea in view. - From Text-AGC

57. Kanter, C.V., and Lunche, R.G.: Emissions and pollutant levels. Trends in Los Angeles. Arch. Environ. Health 8:5-14 (Jan.) 1964.

The concentration of a contaminant in the atmosphere at a given time and place is the result of factors which include the rate of injection into the atmosphere, formation or destruction by chemical interaction, and dilution and transport by air movement. Averages of the trend of particulate matter observed at 4 locations, and sulfur dioxide at 5 locations in the Los Angeles Basin are shown. In L. A. total air pollution surveys and air monitoring activities have provided for understanding of the basic causes of the smog problem, and guiding actions which have slowed the advance of smog. Of the major contaminants discussed, only sulfur dioxide, which is not significantly affected by motor vehicle emissions, has regressed. APCA 5796.

58. Kaskan, W.E.: The source of the continuum in carbon monoxide-hydrogen-air flames. Combustion and Flame (London) 3:39-60 (March) 1959.

The source of the continuum from flames containing carbon monoxide and oxygen has been investigated by measuring both the emission intensity and OH in the flame gases from rich carbon monoxide-hydrogen-air flames. The concentrations of carbon monoxide are calculated from the water gas equilibrium and those of oxygen atoms are calculated from the measured OH. It is shown that the light-producing step involves a reaction between a carbon monoxide mol. and an oxygen atom with a rate constant of 2.7 x 10^{-19} $cm.^3$/mol. sec. In the range of conditions employed the continuum amounts to about 95% of the radiation. The rate of decay of radicals is not much affected by the presence of carbon monoxide and carbon dioxide. - APCA 2406

59. Katz, M., Riberdy, R., and Grant, G.A.: The oxidation of carbon monoxide by solid silver permanganate reagents. Canadian J. Chem. 34:1719-1729, 1956.

The temperature dependence of the rate constant, k, in the heterogeneous oxidation of carbon monoxide on the surface of silver permanganate--zinc oxide, indicates that in the temperature range of about 11° to 40°C., the process is subject to diffusion or transport control and the experimental activation energy is 1.4 to 1.9 kcal. per mole. In the range of 11° to -3°C. the rate of the surface chemical reaction decreases with a corresponding increase in activation energy to 15 kcal. in this transition stage. At lower temperatures the system is subject to chemical control and E rises to about 27 kcal.

Four adsorption isotherms for water vapor on this reagent have been obtained in the range of -10° to 20°C. The isotherms are sigmoid and indicative of Type II adsorption.

The mechanism of this heterogeneous reaction is discussed on the basis of several possibilities for providing oxygen ions in the electron-ion exchange step of the over-all reaction. -Authors' abst.

59a. Kerr, J.A., and Calvert, J.G.: The formation and decomposition reactions of the acetyl radical and the heat of formation of the acetyl radical. Phys. Chem. 69:1022-1029 (March) 1965.

The 3660-Å. photolyses of azomethane in the presence of either carbon monoxide or acetaldehyde have been investigated, and the formation and decomposition reactions of the acetyl radical have been shown to be dependent on the over-all pressure in the system. The activation energies obtained for the decomposition and formation reactions of the acetyl radical are consistent with recent results of O'Neal and Benson. A combination of the present results and recent independent estimates gives $\Delta H_f^\circ(CH_3CO) = -4 \pm 2$ kcal./mole. Results on the reaction (8) $CH_3 + CH_3CHO \dashrightarrow CH_4 + CH_3CO$ have been obtained from the azomethane-acetaldehyde system and together with three other determinations yield the Arrhenius equation: $k_8 = 10^{11.5}e^{-6.8/RT}$ cc./mole-sec. The approximate rate constant for the reaction (10) $CH_3 + (CH_3)_2N_2 \longrightarrow (CH_3)_2NNCH_3$ was derived from the data: $k_{10} = 10^{11.7}e^{-7.1/RT}$ cc./mole-sec. - Authors' Abst.

60. Kirsberg, V.A., and Belozovskii, A. B.: A method for purifying a gas-air mixture of carbon monoxide. Biul Izobret. (Moscow) 22:27-28, 1961.

A method is discussed for purifying a gas-air mixture of carbon monoxide by oxidizing the latter on a hopcalite calalyst. The distinctive feature is that, for the purpose of increasing the degree of oxidation and accelerating the process involved, the gas-air mixture is subjected to the action of ultraviolet rays prior to being fed to the catalyst. - APCA 4600.

61. Korth, W.; Dynamic irradiation chamber tests of automotive exhaust. PHS No. 999-AP-5 U.S.D.H.E.W., PHS, Div. of Air Pollution, Cincinnati, Ohio. (Nov.) 1963 - 54 pages.

As part of an intensive study by government and private agencies the U. S. PHS has built an irradiation chamber facility for investigation of irradiated auto exhaust under mixing conditions similar to those in the atmosphere. The facility consists of a programed continuous-cycling chassis dynamometer, an exhaust dilution-air purification system, 2 irradiation chambers, and exposure facilities for evaluation of bacteria kill, plant damage, and various effects on small animals. Of the 3 variables studied during the 1st test series, the exhaust concentration at the start of irradiation appeared to produce the most significant effects. Fuel composition had a lesser influence. Very little difference was noted in the effects produced at 2 different average irradiation times. - APCA 6065

62. Korth, M.W., and Sigsby, J.E., Jr.: Composition of blowby emissions. Presented at the 57th APCA Annual Meeting, June 21-25, 1964, Houston, Texas

The composition of blowby emissions were evaluated from ten different cars with displacements ranging from 52 in.^{3} to 365 in.^{3} at four different operating modes. Detailed chromatographic analyses were made of the blowby hydrocarbon composition covering a range of approximately 75 components. Nondispersive infrared and flame ionization equipment were also used to determine CO, CO_2 and hydrocarbon concentrations. - Authors' abstract.

63. Kraft, D.: Afterburning of the exhaust gases of motor vehicles. Tech. Uberwach. (Essen) 4:326-328 (Sept.) 1963.

Three methods for the elimination of the components of motor exhaust gases which are injurious to health have been tested. Filtering did not prove successful, but after-burner devices based either on ignition or catalysis methods have shown some positive results. The latter 2 methods are described in some detail. Work on various after-burner devices is being speeded up in the U.S. - APCA 6674

64. Kuley, C. J.: Gas chromatographic analysis of C_1 to C_4 in the parts per million range in air and in vaporized liquid oxygen. Anal. Chem. 35:1472-1475 (Sept.) 1963.

A column has been developed for use with a B-ray ionization detector for the determination of C_2 to C_4 hydrocarbons and for use with a flame ionization detector for C_1 to C_4 hydrocarbons in air and vaporized liquid oxygen. Detectable limits for the B-ray ionization detector are of 0.2 to 0.08 ppm. for C_2 to C_4 hydrocarbons using a 1-cc. or 10-cc. gas sample. Concentrations as low as 0.004 to 0.07 ppm. for C_1 to C_4 hydrocarbons can be detected with a flame ionization detector using a 10-cc. gas sample. Preparation of a modified activated alumina column for the analysis is described. - APCA 5468

65. Lampert, F. F.: Experiments in studying the hygienic effect of garages and gasoline pumps located in the proximity of dwellings. Gigiena i Sanitaria 24:74-76 (March) 1959.

Inspection was made of the hygienic conditions in some residential districts of Moscow. The author found unfavorable atmospheric conditions prevailing in many places where garages and gasoline pumps were located in close proximity to residential dwellings. An analysis of air samples in such areas showed carbon monoxide and lead to be present in inadmissible concentrations. In 1 of the 2 tables in the text the carbon monoxide content in mg./l. is given for several locations. Near the gas pump, the min. concentration was 0.018; the max., 0.036; and the average 0.025. In a dwelling area within 18 m. of the pump, the min. concentration was 0.004; the max., 0.042; and the average 0.023. In a control area, these concentrations were 0.008; 0.021; and 0.012. - APCA 3031

66. Lawther, P.J., Commins, B.T., and Henderson, M.: Carbon Monoxide in Town Air. An Interim Report. Ann. Occupat. Hyg. 5:241-246 (Oct.-Dec.) 1962.

When the Suez crisis resulted in the rationing of petrol it was realized that an opportunity was at hand to measure air pollution in the city of London in the presence of minimal petrol traffic. A series of tests was carried on then and until 6 months after the termination of rationing. When petrol was rationed, CO virtually disappeared from the street; when car-traffic reappeared, the CO concentrations rose markedly and on 1 day reached a figure of 235 ppm. On this calm day, a concentration of 360 ppm. was also found in samplings taken on the pavement at Oxford Circus. Carbon monoxide analyses at Oxford on Sept. 1, 1958, had shown a mean concentration for an 8-hour daytime period of 36 ppm., with a maximum concentration of 155 ppm. during the evening rush hour. In the autumn of 1961, a series of analyses was begun of the air of Fleet Street compared with that of nearly Mitre Court (relatively uninfluenced by traffic). A figure in the text shows the mean hourly concentration, on Jan. 29, 1962, to vary from 0 to nearly 60 ppm. and the maximum concentration at that same hour (18th) to be 100 ppm. Carbon monoxide concentrations in the Blackwell tunnel have been found to reach a mean hourly concentration of 295 ppm. in the morning rush hour. At the Rotherhithe tunnel, a transient peak value of 500 ppm. was found. In the discussion of this paper the authors state that they have been lead to conclude that detailed comparison of carbon monoxide concentration in the air of different cities is of limited value since they will all depend on the density of traffic in the streets and the weather. And that it is reasonable to believe that in congested streets in almost any modern city concentrations of carbon monoxide exceeding 300 ppm. may be reached in calm weather and that concentrations exceeding 100 ppm. may be found not uncommonly. Also that the significance of these figures is not clear-cut since in this study they have not been related to concentrations of carbon monoxide in the blood of people working in the streets. It is stated that the figure of 30 ppm., which has been adopted by the State of California Department of Public Health as the maximum allowable concentration in ambient air, and the arguments on which this decision was based, appear to the authors to be sound. - APCA 5364

67. Lawther, P.J.: Air Pollution. Bull. New York Acad. Med. 41:214-216 (Feb.) 1965.

Following the Beaver report and the pollution control activities which came about following the passage of the Clean Air Act of 1956, smoke is slowly disappearing from the air of Britain but other pollutants are left, notably SO_2. Pollution in Britain is due overwhelmingly to the combustion--both complete and incomplete--of coal and oil, much of which contains compounds of sulfur as impurities. The commonest pollutant, CO_2, is accepted as innocuous; smoke (from incomplete combustion) and SO_2 are measured routinely and are used as indices of pollution. These 2 pollutants vary widely in concentration and are present in roughly the same amounts in New York and London. It is well that in neither city does the topography and climate favor the formation to any significant extent of the photochemical haze which plagues the citizens of Los Angeles, especially since CO from motor vehicle exhausts has been found at levels as high as 360 ppm. on the pavement at Oxford Circus in London. After much hard work it can be said with a degree of certainty that high concentrations of urban pollution, measured in terms of SO_2 and smoke, aggravate existing chronic nonspecific pulmonary disease and may prove to be an intolerable stress to those in a community who are aged or suffering from severe illness. The implementation of the Clean Air Act has radically altered the smoke/SO_2 ratio and it is hoped that it may now be possible to distinguish between the effects of these 2 main pollutants. Studies of daily variations in morbidity and mortality undertaken in London and New York

City (which is low in smoke content of the air) may add much to the knowledge of these 2 pollutants. Laboratory findings of sensitivity to SO_2 and the response of the individual to varying pollution levels, often do not correlate well. Air pollution is, of course, still suspect as an etiological factor in the production of chronic bronchitis but it will be hard to indict it with certainty since it is but 1 of many noxious factors in urban life. Current work would lead to the belief that "classic" carcinogens, such as 3,4-benzpyrene, may have claimed too much attention in recent yrs. to the detriment of the search for more sophisticated mechanisms by which lung cancer may develop. The manner in which asbestos produces neoplasms may have much to teach us with respect to the wider problems of carcinogenesis. - APCA 6773

68. Levaggi, D.A., and Feldstein, M.: The colorimetric determination of low concentration of carbon monoxide. Amer. Indust. Hyg. Ass. J. 25:64-66 (Jan. - Feb.) 1964.

A series of incinerator effluents were analyzed by the procedure described and compared with analysis for carbon monoxide by infrared spectrophotometry and gas chromatography. Carbon monoxide in combustion effluents or in the ambient atmosphere is reacted with an alkaline solution of the silver salt of para-sulfaminobenzoic acid. The absorbance of the resulting colloidal solution of silver is measured spectrophotometrically, and is proportional to the concentration of CO present in the sample. Concentrations of 5 to 1800 ppm. can be measured with an accuracy of 95±5%. - APCA 5906

69. Liesegang, W.: The present position of the hygiene of the atmosphere. Wiener Klinische Wochenschrift 1:463, 1928.

"The use of tar is advocated for keeping dust down on the street. There is no definite proof that smoke has any influence on health. Carbon monoxide in amounts present in Berlin has a pronounced effect on the health of city dwellers." - BAAP 128

70. Likhachev, A.D.: Chromatographic determination of carbon monoxide and oxygen in fuel combustion products. Zavod. Lab. (Moscow) 29:1302-1304, 1963.

The chromatographic analysis of fuel combustion products was conducted on an installation utilizing the separate loops of the KhT-2M chromatograph. Activated carbon served as sorbent and atmospheric air as carrier. The objective of the present investigation consisted in obtaining on the chromatogram a separate and distinct peak for carbon monoxide, which was achieved by using a chromatographic column 480 cm. long, with a 3-4 mm. inside diameter, and with a flow rate of the carrier gas of 50-80 cc./min., the temperature of the gas being 18-20°C. The determination of oxygen was conducted on apparatus GKhP-3M, which registers zero when the ratio N_2/O_2 is equal to 3.76 (as found in un-contaminated air) and shows a peak of maximum height when the gas sample is free of oxygen. The oxygen content is determined as a function of the height of this socalled "excess nitrogen peak." - APCA 6171

71. McCabe, L.C.: Atmospheric pollution. Indust. Eng. Chem. 47:101A-102A (June) 1955.

The Los Angeles County Air Pollution Control Board recently asked a medical and scientific group to set maximum limits at which pollution levels might be dangerous to public health. Limits were established for oxides of nitrogen, ozone, sulfur dioxide, and carbon monoxide, based on judgment and experience. Instruments are now installed at several stations for continuous measurement of these 4 pollutants and also total oxidant, total hydrocarbons, and wind speed and direction. Standard plant boxes, each containing a variety of smog-sensitive plants, are kept at 12 stations for the detection of crop damaging gases; continuous high-volume filters are used to collect ether-soluble aerosols and radioactive materials. It is estimated that some 14,000 tons of combustible rubbish are disposed of daily by burning, two thirds of it in single chamber incinerators. The incineration of this material releases to the air aerosols, aldehydes, oxides of nitrogen, and organic acids which contribute to reduced visibility, eye irritation, plant damage, and general discomfort. There are more than 1,500,000 single chamber incinerators in use in homes and commercial establishments in the county, and they can not be controlled by practicable engineering refinements. Hence, they will be prohibited in unincorporated areas after June 30, when weekly collection of combustible rubbish is established. Incorporated areas (45 in Los Angeles County) have been asked to expand private or public collection service to permit the prohibition of this type of incinerator by July 1. After June 30, new regulations will apply to open burning. - APCA 390

72. McCullough, J.D., Crane, R.A., and Beckman, A.O.: Determination of carbon monoxide in air by use of red mercuric oxide. Anal. Chem. 19:999-1002 (Dec.) 1947.

A new laboratory method for the determination of carbon monoxide in air makes use of the reaction: CO (gas) + HgO (solid, red) = Hg (gas) + CO_2 (gas). The gaseous sample is passed through a reaction tube containing granular red mercuric oxide held at a temperature of 175° to 200° C. The loss in weight of the reaction tube during passage of the sample is an exact measure of the quantity of carbon monoxide present and involves a highly advantageous gravimetric factor. The accuracy of the method has been demonstrated through the analysis of three unknown submitted by the National Bureau of Standards. - Authors' Abst.

73. Marsh, A.: Analysis of the air pollution factor. Smokeless Air 29:42-44, 1958.

This paper reviews the principal ways in which the pollution of the atmosphere impairs the natural environment, and the amount of pollution discharged into the atmosphere of Great Britain. The estimated quantities of the pollutants, from the burning of coal and its derivatives, and from oil/year, are discussed. There are also large quantities of carbon monoxide, hydrocarbons, and other compounds. There are local forms of pollution encountered only in the vicinity of certain industrial works, such as cement, limestone burning, and certain types of chemical plants. Nearly 1/2 the smoke comes from domestic coal-burning fires. This is particularly obnoxious because of its high content of tarry matter and low level of discharge. The ways in which this pollution may affect the health of those living in large towns and industrial areas are: (1) Deprivation of natural light. (2) The respiration of suspended impurity. (3) The deposition of irpurity. The new Clean Air Act gives hope for more rapid progress towards the reduction, and ultimate abolition, of atmospheric pollution. - APCA 2227

74. Mehrstens, J.H.:„ Solution of the problem of the smoke nuisance. Glaser Annalen fur Gewerbe and Bauwesen Vol. 60, 1907.

A general resume of the effects of various constituents of smoke upon health:

"It is not the dust only that is injurious, but it is the invisible products of combustion escaping from the chimney in the form of gases, of which we need to take into consideration only carbonic acid, nitrogen, carbon dioxide, carbon monoxide, sulfur trioxide, sulfur dioxide and sulfurous acid and other heavy gases. Carbonic acid and nitrogen can probably be regarded as injurious only when they are driven directly into dwellings, and this cannot happen unless the chimneys are not high enough. The carbonic acid, which is extremely poisonous, is usually present in such slight quantities that it becomes greatly diffused as soon as it escapes from the chimney. On account of its lightness, it also arises rapidly and is lost in the higher strata of air; but, on the other hand, the gaseous sulfuric acid (sulfur dioxide) which is considerably heavier than air, is such an injurious gas that first of all our efforts must be directed toward preventing it from doing harm, all the more as it is not only the human organism that is injured but also, in a positively destructive manner, the vegetation, soil, and buildings. Those facts show that any smokeless furnace with a direct combustion has little value for the public as far as the purification of the air is concerned unless the dust and the sulfurous acid are retained at the same time." - BAAP 150

75. **Meigs, J.W.: Carbon monoxide poisoning. Bull. U.S. Army Dept. 8:542-546, 1948.**

The danger of carbon monoxide poisoning among men working on gasoline-driven vehicles is emphasized. A concentration of several thousand parts per million may occur in the air near the exhaust outlet, even outdoors, unless exhaust gases are discharged so that the carbon monoxide is diluted before it can return to any area where it may be inhaled. Symptoms, which usually occur when the carboxy-haemoglobin content of the blood reaches 20 percent, include headache, dizziness, faintness, nausea, and vomiting. Samples of oxalated blood should be analyzed for the presence of carbon monoxide as soon as possible after exposure, to minimize reoxygenation of carboxy-haemoglobin, but they can be frozen and sent to a laboratory. The presence of a significant amount of carbon monoxide in the blood will differentiate symptoms due to carbon monoxide poisoning from those due to other causes, especially alcohol. Heavy cigarette smoking may produce carboxy-haemoglobin levels up to 10 percent.- BMB 402

76. Middleton, J.T., and Middleton, D.C.: Air pollution and California's State Control Program. Proc. Amer. Petrol. Inst. 3:636-642, 1962.

Our limited resource is unwittingly being destroyed by man's activities. The destruction of air appears to be correlated with the extent and nature of fuel utilization to meet the energy demands of contemporary society. An increasing knowledge of the causes and nature of air pollution has resulted in changing concepts of control. The state of California, which in 1947 authorized the regulation of stationary sources of atmospheric contamination by local government bodies, is now directly engaged in a program to control mobile sources of contamination through the creation in 1960 of the State Motor Vehicle Pollution Control Board. Air-quality standards developed by the state define both the acceptable air quality and the needed reduction in motor vehicular emissions. While the present program will ensure an improved air quality and thereby reduce damage to health and property, long-range conservation of air will be dependent upon a continuing evaluation of society's fuel utilization, means of transportation, and metropolitan area planning and development. -Authors' Abst.

77. Moureu, H., Chovin, P., Truffert, T., and Lebbe, J.: Some lessons drawn from determinations of carbon monoxide poisoning of city inhabitants. Compt. Rend. (Paris) 247:552-555 (July 28) 1958.

The use of a simple but exact infrared absorption technique to determine the amount of CO in the blood and in the ambient atmosphere is reported. Two experiments were made to study the effects of automobile exhaust gases on 36 volunteer subjects stationed on selected streets and intersections in Paris. The amount of CO in the blood of the subjects was determined immediately before and after a 3-hour period at a test station, and simultaneously 2 or 3 air samples were made to determine percentages of oxygen and CO. The atmospheric conditions and intensity of auto traffic were noted at each station. The first test was made on January 15, 1957, between 9 A.M. and 12 noon; a relatively strong NE wind (20-30 km./hour) prevailed to disperse exhaust gases. The average amount of CO in the air was 8 ppm. The average amount in the blood before exposure (0.35 ml./100 ml. blood), increased about 25% to 0.44 ml. A second test was made 7 days later between 4 and 7 P.M.; wind had been nearly absent for several days and a slight tendency to fog was present. A rise in the initial CO content of the blood was noted, averaging 0.54 ml./100 ml. blood, i.e., slightly exceeding the normal limit for city dwellers of 0.4 ml. The average CO content of 100 samples of air was 26 ppm. The increase in the CO content of the blood at the end of the test period was marked: 0.11 ml., i.e., a 31% increase. Similar tests were made of 136 samples of blood of automobile drivers held on charge of intoxication after an auto accident or traffic offense. Results were statistically analyzed in comparison to 4507 cases suspected of CO poisoning. CO levels in the blood of the intoxicated drivers were found to be much greater than among the controls. - APCA 2023

78. Mulay, A.G.: Catalytic oxidation of carbon monoxide at low concentrations. Dissertation Abst. 22:828 (Sept.) 1961.

A reaction model for the catalytic oxidation of carbon monoxide in air at low concentrations has been established. A commercial catalyst, hopcalite, consisting of MnO_2, CuO, Cr_2O_3, and Ag_2O was used in this investigation. This catalyst (20 U. S. Standard mesh size) exhibited constant catalytic activity even after 50 hours of use. The experimental data were taken at atmospheric pressure and temperatures of 60, 72, and 82°C. At each temperature the rates of catalytic oxidation were measured at initial carbon monoxide concentrations of 1, 1.5, and 2%. Rates of reaction were found to increase with the extent conversion of carbon monoxide, apparently the reaction was catalyzed by the formation and adsorption of carbon dioxide. The rate constants were determined by means of an IBM-704 digital computer. The data were correlated with less than 10% average error. It was found that the adsorption equilibrium constants for both carbon monoxide and carbon dioxide decreased with increase in temperature. This investigation is pertinent to the design of afterburners for removing carbon monoxide from exhaust gases of internal combustion engines. - APCA 4409

79. Murphy, E.J.: Comparison of methods for detecting and analyzing fumes from explosives. USBM RI 5883, 1961, 13 pp.

A comparative study has been made by the Bureau of Mines of several analytical methods for determining carbon monoxide and nitrogen oxides in toxic gases produced by the detonation of explosives. Laboratory and field methods and detector-tube devices are described. Analytical results are compared, and reliability of the various methods is discussed. Author's Sum.

80. Nagarjunan, T.S., and Calvert, J.G.: The photooxidation of carbon monoxide on zinc oxide. J. Phys. Chem. 68:17-26 (Jan.) 1964.

The photooxidation of carbon monoxide on zinc oxide solid has been studied in experiments at 0°. Zinc oxide with presorbed oxygen was irradiated with 3660-Å. light in the presence of carbon monoxide gas. Carbon dioxide was formed in the irradiated system, while its rate of formation in the dark was negligible. The reaction was studied under varied conditions: the temperature at which the oxygen was presorbed on the zinc oxide, the pressure of oxygen during the presorption, the pressure of carbon monoxide gas, the time of irradiation, and the intensity and the wave length of the absorbed light. The results confirm that oxygen is adsorbed in at least three different forms on zinc oxide in an amount which depends on the temperature of the treatment. Two of these types of adsorbed species of oxygen react with carbon monoxide to form carbon dioxide on irradiation, while the third type is inactive. The three types may be O_2-, O-, and O-^{2}, with the first two the active forms. Carbon monoxide appears to react either from the gas phase or from a weakly adsorbed state. The reaction may occur through two different reaction paths, one much faster than the other. The quantum efficiency of the carbon dioxide formation varies from 0.001 at high intensities to greater than 0.1 at low intensities at 3660-Å. Some aspects of the detailed mechanism are considered. From these and other results some speculation is given concerning the contribution of photooxidations sensitized on suspended solid particulates to the chemistry of the polluted atmosphere. There is a high probability that such reactions are of little importance in the usual polluted atmosphere. - Authors' Sum.

81. Nelson, K.H., Grimes, M.D., Smith, D.E., Heinrich, B.J.: Determination of trace amounts of carbon monoxide in gaseous hydrocarbons. Anal. Chem. 29:180-183 (Feb.) 1957.

Methane is added to sample of gaseous hydrocarbons to aid in the separation of trace amounts of carbon monoxide from the hydrocarbons by low temperature fractional distillation. Methane which boils between carbon monoxide and the hydrocarbons, does not interfere in the subsequent determination of carbon monoxide by combustion over hot iodine pentoxide. The liberated iodine is determined spectrophotometrically. - APCA 1519

82. Oppenheim, U.P.: Experimental Verification of Theoretical Relations Between Total Gas Absorptivities and Total Gas Emissivities for CO. Guggenheim Jet Propulsion Center, Calif. Inst. of Technol., Pasadena, Oct. 1958, 14 pp., 4 Fig. DDC AD 204287.

An experimental study was carried out for the purpose of verifying theoretical predictions concerning the relations between total absorptivities and total emissivities for transparent gases. The experimental conditions were designed in such a way as to permit a direct check of theoretical relations derived for (a) non-overlapping dispersion lines and (b) spectral lines with sufficient pressure broadening to permit neglect of the rotational fine structure. A comparison between the emissivities derived from absorptivity measurements and emissivities calculated from the spectroscopic constants of CO shows good agreement (within 20% for most of the temperature range).

The apparatus for the measurement of total gas absorptivities is described. Results for total absorptivities of carbon monoxide measured at temperatures between 300 and 500°K are given and total emissivities were calculated in the temperature range of 300 to 1600°K. The range of total gas pressure is 0 to 515 psia. - Author's Abst.

83. Paulin, P.: Sensitive Method of Detection and Determination of Carbon Monoxide in the Atmosphere. Bull. Soc. Chim. France (Paris) 11-12:1845-1849 (Nov.-Dec.) 1959.

The reduction of $AuCl_3$ (on an impregnated filter paper) by a drop of AS_2O_3 is accelerated in the presence of CO. It has been shown that the time of appearance of reduced Au, as a black ring on the paper, is inversely proportional to the cube root of CO concentration. Interference by other gases which darken the paper (H_2S, AsH_3, acetylene, aniline, SO_2, acetone, and Hg vapor) or by acid vapors which delay the appearance of the ring is discussed. Some interference can be reduced by Chaignon's method, in which the paper is held between 2 plates of glass to exclude less rapidly diffusing gases. Quantities of CO of the order of 1 in 10^5 can be detected with a time appearance of the black ring of 115 seconds at 20° and 275 seconds at 5°. - APCA 4743

84. Perrelli, G., and Rosettani, E.: Criteria of evaluation of the environmental risk from carbon monoxide. Folia Med. 47:1062-1067 (Nov.) 1964.

The authors give a brief survey of environmental means of detection of carbon monoxide and then underline that it is difficult to obtain an adequate determination of industrial hazards by these methods. It is therefore believed that carboxyhemoglobin determination might offer a greater accuracy. - APCA 64-279

85. Petri, H.: Evaluation of the effects of gaseous air pollutants on health. Staub 25:416-423 (Oct.) 1965.

Many gases and vapours in molecular dispersion have pathophysiologic effects, that is, effects dangerous to health. Various substances can be detected by smell even if present in air in small quantities, and at a certain concentration they may become a nuisance; these substances are, for instance, mercaptans, butyric acid, acrolein and amines, such as trimethylamine; hydrogen sulphide, carbon disulphide, pyridine, etc. cause nuisance at slightly higher concentrations. Sulphur oxides, hydrogen fluoride and other acid aerosols, further, ozone, chlorine, bromine and nitrous gases are dangerous to health, because they irritate body tissue. As a result of the increase in road traffic the odorless carbon monoxide has become very important. The biological assessment of gas or vapour emission with regard to their effect on men, and special effects of these substances are discussed in detail. - Author's Sum.

86. Porter, K., and Volman, D. H.: Flame ionization detection of carbon monoxide for gas chromatographic analysis. Anal. Chem. 34:748-749 (June) 1962.

Carbon monoxide may be detected by a flame ionization detector after catalytic conversion to methane. A high percentage conversion is obtained, mainly independent of catalyst temperature over the operating range. This method is more sensitive that katharometer detection. Carbon dioxide and hydrogen may be detected by use of the same nickel catalyst. - APCA 4624

87. Portheine, F.: Medical problems of air pollution. In: Fachtagung des Städtetages Nordrhein-Westfalen über Massnahmen zur Reinhaltung der Luft in Städten, Jan. 8, 1958, Wuppertal. Städtehyg. (Uelzen) 10:59 (March) 1959.

Man in the course of a life of 68 years, in securing his oxygen requirements, breathes 1/3 to 1/2 million m.^{3} of air. Each living person has a right to pure air. Because of the great increase in industrial production in the last 10 years, there exists the danger of increased pollution of the air. An additional source of danger comes from atomic research. The number of power-driven vehicles in the world has reached a billion. The most dangerous sources of pollution emit a dust which is becoming finer and thereby more capable of entry into the lungs. Many injuries are not currently known since the living organism is capable of adapting itself. The latter is physiologically possible and is especially noted in industrial plants. Even an adaption of the mucous membranes to high concentrations of SO_2 has been observed. The dust cloud covering a city, filters out the solar radiation. Inhabitants of a city are apt to become aware of this only on Sundays and on vacations. Remedial measures are the planting of trees and other vegetation, decentralization of the cities, provision for free-flowing traffic, and improvement of car engines. According to the author, the effects of coarse dust are over-estimated. The nature of the pollutants is important, whether the particles are sand or quartz, ashes, or soot. Russian methods control pollution effectively. Soot combined with SO_2, or soot combined with vanadium compounds, are very noxious. In driving cars in long lines through narrow streets, the CO concentrations in the blood of drivers and passengers may be markedly increased. - APCA 2985

88. **Procedures and Analytical Methods for Determining Toxic Gases Produced by Synthetic Materials. Procedures for Flash-Ignition and Self-Ignition Temperature Determinations. United States Testing Company, Inc., Hoboken, N.J., Dec. 1963, 49 pp. DDC AD 297457.**

Equipment, procedures and analytical methods for determining the nature and concentration of toxic gases produced when synthetic materials are subjected to flammability tests are described. A method for flash-ignition temperature determination is given. The necessary equipment and a procedure for determining the self-ignition temperature of heat resistant material is described. - Authors' Abst.

89. Rice, E.W.: Improved photometric determination of carbon monoxide by means of palladious chloride. Arch. Indust. Hyg.& Occupat. Med. 6:487-490 (Dec.) 1952.

Details are given for a method for detection and determination of carbon monoxide involving reduction of palladious chloride in which the palladium can be estimated spectrophotometrically, instead of colorimetrically, as palladious iodide. This method was devised as a test for the toxicological determination of carbon monoxide. - LC

90. Rihm, A., Jr.: New York State's classifications-ambient air quality objectives system. J. APCA 15:519-522 (Nov.) 1965.

The air pollution potential of any area is directly related to its population and economic development. In New York State, this pollution potential ranges from that existing in the sparsely inhabited recreational zones to that prevailing in the densely populated and/or heavily industrialized areas. No one set of air quality standards or objectives can be developed which can reasonably be applied on a statewide basis. A classifications-air quality objectives system has been adopted by the State Air Pollution Control Board for application in New York State. In accordance with this system, specific areas can be classified in one of 16 categories. Air quality objectives, in keeping with each classification, are designed to protect health and to promote the maximum comfort and enjoyment and use of property consistent with the needs of the area concerned. The system was developed by the staff with the assistance of a council of technical advisors. Units of measurement related to the most important effect of specific contaminants are utilized. Methods of sampling and analysis are specified. The details of the classifications-objectives system, the place of the system in the state's air resource management plan, the manner in which each segment of the state after study will be classified, and how attainment will be evaluated are described. - Author's Abst.

91. **Sakabe, H., Soda, R., Matsumura, Y., Honma, K., and Nozaki, K.: Air pollution study at heavy traffic road. Bull. Nat. Inst. Indust. Health (Japan) 4:72-76, 1960.**

Carbon monoxide determinations were made by means of Kitigawa colorimetric tubes at the center of a heavy traffic Y intersection in Tokyo on March 3 and 4, 1960. Samples were collected every hour from 8 through 11 A.M., 2 P.M. and every hour from 3 to 7 P.M. on both days omitting the 11 o'clock sample on March 4. Concentrations ranged from 2.5 to 10.0 ppm on March 3 with a mean of 5.0 ppm. On March 4, the range was from 4.8 to 20.2 ppm with a mean of 12.2 ppm. - PHS-RG 5676

92. Salsbury, J.M., Cole, J.W., and Yoe, J.H.: Determination of carbon monoxide: Microgravimetric method. Anal. Chem. 19:66-68, 1947.

A microgravimetric method, accurate to about 2 percent, is described for low concentrations (0.002 to 0.1 percent) of carbon monoxide in air. The gas is drawn over Hopcalite at 195° C., and the carbon dioxide thus formed is absorbed in microabsorption tubes containing Ascarite, the volume being measured with a flowmeter and stop watch. From the weight of carbon dioxide absorbed in the tubes, the percentage of carbon monoxide is calculated. - Authors' Abst.

93. Sayers, R.R., Yant, W.P., and Jones, G.W.: The pyro-tannic acid method for the quantitative determination of carbon monoxide in blood and air. Pub. Health Rep. 38:2311-2320 (Oct. 5) 1923.

A durable and compact laboratory or field apparatus for the quantitative determination of carbon monoxide in blood and air has been described. On account of the compactness, durability, and ease with which accurate and dependable results can be obtained, it should be of great use in investigations pertaining to the cause, diagnosis, and treatment of carbon-monoxide poisoning.

The percentage saturation of CO in blood can easily be determined to a degree of accuracy involving only 5 per cent error.

The actual error of the method for determination of CO in air, even when used by inexperienced men, was found to be 0.005 in regions of 0.000 to 0.05 per cent CO; 0.01 in regions of 0.05 to 0.08 per cent; 0.02 in regions of 0.08 to 0.12 per cent; and 0.03 in regions of 0.12 to 0.18 per cent carbon monoxide. - Authors' Sum.

94. Schrenk, H.H.: The chemistry of smog. Indust. Hyg. Newsletter 10: 7-9, 1950.

The word "smog" has come to refer to the sum of air contaminants, not the particulate matter alone. The chemistry of smog is an essential factor in its evaluation and control. The sources, formation, and interrelationship of the contaminants are discussed, using combustion of coal and production of zinc as examples and showing that the reactions and interrelationships may be quite complex. A number of questions calling for increased study are raised. The Donora (Pa.) investigation furnished some experience in developing methods for answering these questions. The weather is an important factor in smog production. The five substances contributing most to the atmospheric load are: Total particulate matter, sulfur dioxide, total sulfur, carbon monoxide, and carbon dioxide. A number of others in smaller quantities contribute to the total effect. The toxicology of the single substances is fairly well known, but the physiological action of mixed gases and the influence of aerosols is an almost unexplored field. - BMB 664

95. Sendroy, J., Jr.: Manometric analysis of gas mixtures. VI. Carbon monoxide by absorption with blood. J. Biolog. Chem. 95:599-611, 1932.

A method is described, whereby air containing carbon monoxide in concentrations from 0.05 to 0.3 per cent may conveniently be analyzed in the Van Slyke-Neill apparatus. The CO is first combined, in the chamber of the apparatus, with the hemoglobin of completely reduced blood, and the CO content of the blood is then determined by the method of Sendroy and Liu. - Author's Sum.

96. Shapritskii, V.N.: Characteristics of emissions into the atmosphere from iron- and steelworks. Stal in English (London) 1002-1004 (Dec.) 1964.

To develop a complete series of technologically sound measures to protect the atmosphere, it is necessary to consider the emissions from each shop of an iron- and steelworks. Such calculations have been carried out at "Gipromez" (the State planning institute for iron- and steelworks). In Table I in the text the quantity of emissions per ton of basic shop production, or of steel melted at the works, is compared with their value after the introduction of measures that are technically possible at the present time for protecting the air supply (scrubbing of gases, rational distribution of gas fuel throughout the works, etc.). Table II presents the emissions from the shops of a works with a complete metallurgical cycle with the following basic types of production (in millions of ton's per annum): Steel (1.0); pig iron (0.85); rolled products (0.8); sinter (1.5); coke (0.5); and refractories (0.03). Table III presents the approximate consumption of fuel in the separate shops, from which it is possible to calculate a preliminary rational distribution of various types of fuel over the works area, depending on fuel consumption, flue height, local relief, and the make-up of sources. The data presented make it possible to determine the total quantity of dust, sulphur dioxide, and carbon monoxide in the flue gases, and to distinguish the sources to which attention should be paid in the first instance in deciding upon measures to protect the atmosphere. The data show that by carrying out a series of protective measures, the emission of harmful substances into the atmosphere can be reduced, in the case of dust by a factor of 14, in the case of sulphur dioxide by a factor of 3 (in residential areas the content of either in the atmosphere should not exceed 0.5 mg./m.^{3}), and in the case of carbon monoxide by a factor of 1.2 (its upper permissible concentration is 6 mg./m.^{3}). - APCA 64-217

97. Shaw, J.H., and Howard, J.N.: Carbon Monoxide in the Earth's Atmosphere. Ohio State Univ. Res. Foundation, Columbus, July 17, 1953, 79 pp. DDC AD 21104.

The abundance of CO in the earth's atmosphere above Columbus, Ohio, has been determined from measurements of the curves of growth of the rotational lines P(6) in the 2-0 overtone vibration band near 2.3μ and R(2) of the 1-0 fundamental band near 4.7μ. Abundances of approximately 0.1 atmo-cm in a column through the zenith were obtained. A discussion is given of the theoretical assumptions made in calculating the abundance and a detailed account of the experimental procedure is presented. - Authors' Abst.

98. Shaw, J.H.: A determination of the abundance of nitrous oxide, carbon monoxide, and methane in ground level air at several locations near Columbus, Ohio. Geophysics Research Direc. Cont. No. AF 19(604)2259. Sci. Rept. No. 1. Ohio State University Res. Foundation. Columbus, Ohio. June 1959. 38 pp.

Studies of the infrared spectra of long path lengths of air (704 m.) permitted determination of the abundance of nitrous oxide (N_2O), methane (CH_4) and carbon monoxide (CO) in ground level air. There would appear to be two possible sources of the nitrous oxide in the atmosphere. The gas may be produced by an aerobic bacterial decomposition of nitrogen compounds, or it may be formed from nitrogen and the various forms of molecular oxygen in the atmosphere. In this study the N_2O abundance was estimated as 0.28 ± 0.04 ppm. with no seasonal variation detected. Air samples from greenhouses and barns showed an N_2O abundance of 0.33 ± 0.04 ppm. The estimated abundance of CH_4 and CO in ground level air were 2.4 and 1.1 ppm., respectively. It was noted that the results for ground level air were uniformly lower than the results from solar spectra, indicating the possibility that N_2O may not have a uniform vertical distribution, assuming that both methods have about the same accuracy. Results of spectrometer studies indicated that a better method for compensating for H_2O absorption in the 4.5 μ and the 3.3 μ region of the band would improve the data; work is now being done on methods for removal of H_2O. Air samples are being collected from various other locations such as silos, sewers, congested traffic areas, farms, etc., in the hope that this data will give more information on the origin of N_2O. - APCA 3671

99. Shepherd, M.: Rapid determination of small amounts of carbon monoxide. Preliminary report on the NBS colorimetric indicating gel. Anal. Chem. 19:77-81 (Feb.) 1947.

This condensed report furnishes the minimum preliminary information necessary to make and use the NBS indicating gel for the rapid colorimetric determination of small or physiologically significant amounts of carbon monoxide in air in the field or laboratory. The gel will detect and estimate less than 1 part of carbon monoxide in 500,000,000 parts of air. It will detect 0.001% by volume in less than 1 minute, and determine physiologically significant amounts in approximately 1 minute. Field use requires a small, inexpensive apparatus without maintenance problems, and involves procedures so simple that untrain personnel will be able to obtain reliable results. - Author's Abst.

100. Shepherd, M., Schuhmann, S., and Kilday, M.V.: Determination of carbon monoxide in air pollution studies. Anal. Chem. 27:380-383, 1955.

Field and laboratory methods of determining carbon monoxide in air by colorimetric indicating gels have been developed. The field method compares commercially prepared tubes with fixed color standards painted or printed on paper. Air is drawn through the indicating tube and the presence of carbon monoxide is indicated when the yellow gel turns green. The field method is widely used where physiological considerations are important, but it is not sufficiently accurate for careful studies in air pollution. Refinements of this method permit estimation of 1 to 0.1 ppm. The laboratory method can detect and estimate extremely small amounts, such as 1 part in 500,000,000. - APCA 267

101. Silverman, L., and Gardner, G.R.: Potassium pallado sulfite method for carbon monoxide detection. Amer. Indust. Hyg. Ass. J. 26:97-105 (March-April) 1965.

This paper describes an improved method for directly measuring low concentrations of carbon monoxide in air. Carbon monoxide reacts with potassium pallado sulfite impregnated on a chemically inert gel contained in sealed glass tubes. Length of discoloration caused by conversion of yellow sulfite to dark brown palladium or its oxide is an exponential function of CO concentration. Data are presented on the measurement of carbon monoxide in air as well as in oxygen-deficient or oxygen-free atmospheres. Applications are given relative to interfering and non-interfering gases and vapors as well as temperature correction data covering range of -50°F to 120°F and ambient pressure correction. - Authors' Abst.

102. Skvortzova, N.N.: Pollution of atmospheric air with carbon monoxide in the vicinity of ferrometallurgical plants. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 2, 1960, pp. 204-212, CFSTI-TT-60-21188, U.S. Dept. of Commerce, Springfield, Va.

Author describes a Study made of the atmospheric air surrounding ferro-metallurgical plants. Concentration of CO ranged between 5.6 - 190 mg/m^3, and in 78.8 - 93.5% of the samples CO concentrations exceeded the allowable limit for maximal single concentrations for the atmospheric air. Results of simultaneous studies of the atmospheric air and the air in dwellings showed a similarity between the CO concentrations. Children, observed during this study, showed a high content of carboxyhemoglobin, and a large percentage of the children developed erythrocytosis, accompanied by subjective complaints, characteristic of CO poisoning.

Author points to the urgent need for abatement of air pollution in particular of CO, because of its deterimental health effects, especially of its effect on young children. -AGC.

103. Smith, R.N., Swinehart, J., and Lesnini, D.G.: Chromatographic analysis of gas mixtures containing nitrogen, nitrous oxide, nitric oxide, carbon monoxide, and carbon dioxide. Anal. Chem. 30:1217-1218 (July) 1958.

A gas chromatography column using 2 layers of silica gel separated by iodine pentoxide makes possible the separation and determination of nitrogen, nitrous oxide, nitric oxide, and carbon monoxide or nitrogen, nitric oxide, carbon monoxide, and carbon dioxide in 10 minutes. Simple gas sampling and gas transfer units made from standard equipment are described. - APCA 1869

104. Sobolev, G.K.: High-temperature oxidation and burning of carbon monoxide. Seventh International Symposium on Combustion at London and Oxford, 28 Aug.-3 Sept., 1958. Butterworths Scientific Publications, London, 959 pp., 1959, pp. 386-391.

The purpose of this study was to measure the rate of burning of CO in the flame front, using the results of normal flame velocity measurements for this purpose, and simultaneously to make direct measurements of the rate of oxidation of CO in the after-burning zones of the same flames. A comparison of the data obtained by these two independent methods will evidently be not only of theoretical but of practical value as well. - Author's Abst.

105. Sorakina, S.F.: A study of carbon monoxide concentrations in the air of living dwellings and its effect on organism. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 8, 1963, pp. 207-213, CFSTI-TT-63-11570, U.S. Dept. of Commerce, Springfield, Va.

This paper deals with investigations of the carbon monoxide content of the air in apartments with gas facilities for heating and cooking purposes. The CO concentrations of the 895 samples collected were determined by conductometric methods. Sixty-five of the eighty persons interviewed complained of head-ache, pain around the heart, vertigo, nausea, vomiting, general debility, etc. Housewives examined showed an average hemoglobin content of 77-80%, against the normal 70-71%, with elevated erythrocyte counts. Blood carboxyhemoglobin was above 9% in 62% of the investigated persons, the average was 9.5-10%. About 33.5% of the housewives which were investigated showed symptoms of hypotonia and hypothermy. General chronaxy in the persons investigated was delayed as compared with the controls. Author states that subjective complaints, blood changes, arterial blood pressure and increase in chronaxy in chronic exposure to the inhalation of carbon monoxide cannot be accounted for by anoxy alone; the direct action of carbon monoxide on tissues and cells of organisms must also be taken into account. - A.G.C.

106. Spector, N.A., and Dodge, B.F.: Colorimetric method for determination of traces of carbon dioxide in air. Anal. Chem. 19:55-58 (Jan.) 1947.

A colorimetric method for determining traces of carbon dioxide, using a Lumetron photoelectric colorimeter, depends on the decrease in color intensity of a solution of sodium hydroxide colored with phenolphthalein indicator. The alkalinity of the solution decreases as it absorbs carbon dioxide from the gas sample to be analyzed and consequently the depth of color decreases. The change in the amount of light which the solution transmits is made a measure of carbon dioxide concentration. The precision and sensitivity of the method are functions of the carbon dioxide concentration as well as the volumes of the gas sample and absorbing solution. In general the precision increases with increase in carbon dioxide concentration being measured, with the use of larger gas samples and, within limits, with the use of smaller volumes of absorbing solution. The accuracy of the results is considered to be of the same order as the precision. A 1-liter gas sample is sufficient to determine a carbon dioxide concentration in air of 0.0010% (10 p.p.m.) with a precision of 10%--i.e., ± 0.0001%. - Authors' Abst.

107. Stepanovich, A.: Determination of carbon monoxide in air. Glasnik Higienskog Institute 4:77-85, 1955. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related

Occupational Diseases. A Survey. Vol. 1, 1960, pp. 151-160, CFSTI-TT-60-21049, U.S. Dept. of Commerce, Springfield, Va.

The palladium chloride method for the determination of CO in the air can be used conveniently in the field. It is easy to perform, can be used for CO concentrations ranging between 0.001-05%, and is well adopted for the determination of concentrations usually found in industrial establishments. A field worker can be trained to collect and analyze 10 air samples a day. Range of error is ±4%.

Commercially produced materials and apparatus used in the detection of CO in the air should be checked and used in strict conformity with the instructions supplied.

Indicator paper strips can be used reliably for the detection of CO concentrations exceeding the allowable limits.

At no time should a single CO determination be regarded as reliable or indicative. Air of industrial work rooms should be examined over long periods of time in order to obtain reliable average maximal concentrations of CO in the air of industrial shops and workrooms. - Author's Conclusion

108. Sturrock, P.E., and Kitzes, G.: An Estimation of Exposure to Carbon Monoxide by Breath Analysis. WADC Technical Report 57-291, March 1958, DDC AD 118274, pp. 11.

A semiquantitative screening method for determination of carbon monoxide poisoning in human subjects is presented. The method is based upon measurement of the carbon monoxide concentration of the breath with the National Bureau of Standards' colorimetric carbon monoxide-indicating gel. The results of a "smoker-nonsmoker" survey of 54 Aero Medical Laboratory personnel are included to show the significance of the method in measuring incipient carbon monoxide-exposure levels. The method has an accuracy of ±2% blood-carbon monoxide saturation. It is rapid, easy to use, and supplements the use of blood specimens. - Authors' Abst.

109. Swartz, D.J., Wilson, K.W., and King, W.J.: Merits of liquified petroleum gas fuel for automotive air pollution abatement. J. APCA 13:154-159 (April) 1963.

A major result of this investigation is to provide new data emphasizing the striking differences in the composition of exhaust gas from similar engines operating on liquified petroleum gas (LPG) fuel as contrasted with their operation on gasoline. Our tests show that in the case of LPG exhaust there are essentially no heavy hydrocarbons (C_4 or greater) present. Since the olefins are the worst offenders as regards smog formation from gasoline exhaust, the absence of heavy olefins in LPG exhaust suggests the possibility of a significant reduction in automotive smog if enough vehicles in a given area use LPG fuel. The sealed fuel system offers an additional advantage by eliminating the evaporation of fuel to the atmosphere, which is currently a source of added expense to the motorist as well as adding to the total amount of air pollution from cars. - Authors' Conclusion

110. Taylor, G.J.: Trends in air pollution outside Los Angeles County. Arch. Environ. Health (see 6th APM Conference) 8:15-18 (Jan.) 1964.

The basic air pollution problems as prevailing in Los Angeles County are discussed. The State Department organized a 16-station statewide network in cooperation with local air pollution agencies permitting the collection for the first time of statewide data on carbon monoxide and hydrocarbons. In the fall, 1961, during a period of very light winds, the carbon monoxide recorder set up in downtown Sacramento recorded seven days of carbon monoxide pollution which exceeded the "serious" level set by the Department's Air Quality Standards, i.e., 30 ppm. average over 8 hours. Extension of monitoring activities into new areas are contributing to new findings. - AGC

111. Tebbett, R.W.: The detection and estimation of carbon monoxide. Ann. Occupat. Hyg. (London) 5:201-210 (Oct.-Dec.) 1962.

A brief outline of the various methods which are available for the detection and estimation of CO is given. Colorimetric detection methods, based on the reduction of palladous salts are described with particular reference to the use of the P. S. detector and the M. S. A. tubes. For more precise estimation, the use of Sleigh or Haldane apparatus is recommended when dealing with high ranges of CO (above 0.02%) while the Wosthoff apparatus should be used for quantities in the ppm. region. For process control both the infrared gas analysis method and the oxidation method, based on hopcalite, are satisfactory. A description is given of a portable monoxide detector and alarm designed by the N. Western Div. of the Natl. Coal Board which should find applications in many industries where carbon monoxide constitutes a hazard. - APCA 5259

112. Truhaut, R., and Lemoan, G.: On the quantitative determination of carbon monoxide in the air and in biological environments. Progr. med. (Paris) 87:427-435 (Dec. 10) 1959.

Recognized methods for the quantitative determination of carbon monoxide, in either the blood or the atmosphere, are numerous but those methods being currently used in laboratories for toxicological and biological analysis are limited. For quantitative determination of the gas in the atmosphere, analysis of the blood has been used both to act as a method of reference and independently. But it is not as much used currently as the method of infrared absorption, the latter being more sensitive and easily executed. A method, although less specific and less exact, which permits a continuing evaluation of the atmospheric content is that of an indicator method which is based on the reduction of the salts of palladium. Determination of CO in blood by the method of Nicloux Bull. Soc. Chem. Biol. 75:57-60 (1913) gives excellent precision but involves a delicate and lengthy technique. The employment of infrared absorption has the disadvantage of needing to be done in certain specialized laboratories where the equipment is available. In the clinical laboratories a diffusion method utilizing the reduction of palladium salts has proved to be a simple, sufficiently sensitive method which can be used to determine both the acute and the subacute levels of CO. The latter level is becoming increasingly important in current industrial hygiene practices. - APCA 3213

113. Turkel'taub, N.: Determination of carbon monoxide with the aid of a gas analyzer. Zhur. Analit. Khimii, Vol. 5, No. 4, 1950. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 1, 1960, pp. 161-162, CFSTI-TT-60-21049, U.S. Dept. of Commerce, Springfield, Va.

Carbon monoxide is oxidized with the aid of a red-hot platinum wire spiral in a special apparatus. The resulting carbon dioxide is absorbed by a given volume of 0.005 or 0.01 N barium hydroxide

$$Ba(OH)_2 + CO_2 = BaCO_3 + H_2O.$$

The quantity of carbon dioxide is determined by the difference in titrations against HCl before and after the air sample is passed through the oxidizing (combustion) chamber. The sensitivity and accuracy of the method was found to be 0.0014 mg. - Author's Introduction

114. Ulrich, S.S.: Carbon Monoxide Contamination Tests on Various Vehicles. Lab. Division Develop. and Eng., Detroit Arsenal, Mich., Dec. 18, 1953, 6 pp. and 8 Tables. DDC AD 25822.

Environmental factors influence the percentage of CO contamination in a vehicle for a given period of time. Four of the vehicles tested indicated the production and retention of dangerous CO percentages. A standard operating procedure for duplication of test results was not established because environment was not sufficiently controllable. - Author's Abst.

115. Vanderwerf, D.: A study of the temperature dependance of the total absorptance of CO near 4.7 microns and 2.3 microns and CH4 near 3.3 microns. Masters' Thesis. Ohio State Univ. Res. Foundation, Columbus, Ohio, May 1964, DDC-AD-442 926.

The dependence of the total absorptance of the bands of carbon monoxide near 4.7 microns and 2.3 microns, and of methane near 3.3 microns, on absorber concentration, pressure, and temperature was measured.

Data were taken for absorber pressures between 100 and 1,000 MM HG, and at temperatures up to 400 C, for a fixed absorber path length of 30.6 CM.

The nature and possible reasons for the observed temperature dependence of the total absorptance are discussed. - Author's Abst.

116. Van Slyke, D.D.: Studies of acidosis. II. A method for the determination of carbon dioxide and carbonates in solution. J. Biol. Chem. 30:347-368, 1917.

A simple one piece apparatus is described for determination of the carbon dioxide or carbonate content of water solutions. It has been designed especially for anlaysis of 1 cc. samples of blood plasma, but is applicable to water solutions in general as well as to the determination of dissolved gases other than carbon dioxide.

The entire analysis is performed at room temperature, requires about 3 minutes, and without especial precautions is capable of accuracy to within 1 per cent of the amount determined.

A micro-apparatus designed on a similar principle is described. With it the carbon dioxide content of 0.2 cc. of plasma can be determined with an accuracy of 1 volume per cent. - Author's Sum.

117. Van Slyke, D.D., and Robscheit-Robbins, F.S.: The gasometric determination of small amounts of carbon monoxide in blood, and its application to blood volume studies. J. Biol. Chem. 72:39-50, 1927.

This paper presents a developement of the blood carbon monoxide methods of Van Slyke and Salvesen and of Harington and Van Slyke with attention to certain details which reduce the error to 0.02 or 0.03 volumes percent. A technique is described for quantitative gasometric determination of small amount of carbon monoxide in blood. The present procedure was develope primarily to make possible the determination of blood volumes by the carbon monoxide method of Grehant and Quinquaud without saturating, as has previously been necessary, as much as one-third of the blood hemoglobin with CO in order to obtain accurate results. A technique requiring the saturation of only one-tenth to one-twenthieth of the circulating hemoglobin makes the method more safe and convenient for use with human subjects, and with animals permits the introduction of CO by intravenous injection of CO-saturated blood instead of by inhalation of the gas. It appears that 4 minutes after injecting carbon monoxide blood as described in this paper one can estimate the volume of the circulating red cells from the blood CO content with less than 5 per cent error due to analytical technical and CO distribution within the blood. We have not ascertained the magnitude of the possible additional error due to diffusion of CO from blood to tissue hemoglobin. - Authors' Sum. Modified.

118. Vaskevich, D.N., Bulycheva, A.I., and Mel'nikova, P.A.: Rapid method for the determination of carbon monoxide in the air of working premises. Vodosnozhenie i Sanitarnaya Tekhnika, No. 1, pp. 12-13, 1956. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 7, 1962, pp. 97-101, CFSTI-TT-62-11103, U.S. Dept. of Commerce, Springfield, Va.

Present method used for carbon monoxide determination is based on the oxidation of carbon monoxide to carbon dioxide by iodine pentoxide, presents considerable difficulties when it becomes necessary to collect and analyze many air samples in a short time. The authors describe an indicator method for the determination of low carbon monoxide concentrations in the air of production premises, an improvement over the present complicated procedure. The method described in detail is based on passing the test air for 3-5 minutes through an indicator tube filled with a special white powder. As the CO passes through the tube, the powder acquires a greenish violet color, the intensity of which is proportional to the CO concentration in the air. The intensity of the developed color is then compared with the color of a specially prepared standard series of tubes representing CO concentrations in the range of 0.01-0.4 mg/li. The procedure requires 10 minutes and the determination can be made directly on the spot. Table shows comparative data of CO determinations by standard method and by the new indicator method. - AGC

119. Walker, J.K., and O'Hara, C.L.: Analysis of automobile exhaust gases by mass spectrometry. Anal. Chem. 27:825-828 (May) 1955.

Mass spectrometer techniques for the analysis of automobile exhaust gases (CO), and a sampling procedure for laboratory gas analysis are presented. These data are supplemented by results from continuous monitoring of exhaust gas composition at various engine speeds. The hydrocarbon content of automobile exhaust varies with engine speed, approaching steady state at high speed. The oxides of nitrogen produced, as indicated by continuous analysis, show an increase with engine speed. - Authors' Abst.

120. Waller, R.E., Commins, B.T., and Lawther, P.J.: Air pollution in a city street. British J. Indust. Med. 22:128-138 (April) 1965.

Measurements of the concentrations of smoke, lead, and five polycyclic hydrocarbons in the air have been made in the City of London in the middle of a busy street and at two control sites. Samples were taken only throughout the daytime hours on weekdays to enable us to assess the maximum contribution made by traffic to the pollution in the street. The results showed that during these periods the air in the middle of the street contained three times as much smoke, four times as much lead, and 1.7 times as much 3:4-benzpyrene as were present in the general atmosphere of the City of London as estimated from samples taken at the control sites. One of these sites was chosen because it was only 150 feet away from the street; analyses yielded no evidence that the traffic contributed to the pollution sampled there. Sulphur dioxide concentrations were determined in the early part of the study and the results showed that traffic appeared to add little to the background level. The concentrations of lead found were below those held to be safe by many authorities. Carbon monoxide concentrations, reported in greater detail elsewhere, sometimes reached the accepted industrial maximum allowable concentration of 100 p.p.m. - Authors' Abst.

121. **Wanta, R.C., and Stern, A.C.: Classification of air pollution exposures. Amer. Indust. Hyg. Ass. Quart. 18:156-160 (June) 1957.**

The concentration, averaging-time, recurrency triad has been introduced, and its significance and some of its properties for air pollution have been explained. Application has been made to familiar air pollution incidents of the past. It is suggested that research efforts employing the triad approach require enlargement, if not stimulation, in order to improve our ability to assess the kind of air environment toward which communities are now tending, and in the expectation that short-term methods of assessing long-term effects will eventually become successful. - Authors' Abst.

122. Wilke, H.: Advantages and disadvantages of methods of supervision of firings on the formation of soot. Wasser Luft Betrieb (Wiesbaden) 6:104-109 (March) 1962.

Considerable information is given on the amount of excess air, or oxygen, necessary to assure complete combustion of various fuels including gas, oil, brown coal, anthracite coal, and hard coal, in an effort to prevent soot-formation. Also given is information on the amount of CO_2 produced when combustion conditions are controlled. A diagramatic drawing of a scheme for producing soot-free combustion is shown in a table in the text. Also shown are schemes for continuous measuring of CO_2, CO, and H_2 near a combustion unit, and for construction of an optical-electrical soot registering system. - APCA 5506

BIOLOGICAL

Animals

effect of acute (short term and severe)concentrations

123. Burda, A.S., and Oborin, N.A.: Therapeutic effect of Cytochrome C in acute carbon monoxide poisoning in animals. Gigiyena Truda i Professional'nyye Zabolevaniya 7:56-57 (Aug.) 1963.

The search for new antibiotics to combat CO poisoning is of great practical importance. The need for this effort stems from the variety of mechanisms that regulate the development of the pathological process in acute CO poisoning. This paper describes investigations revealing impairment of the enzymatic systems, especially the respiratory enzymes of the brain. The direct injurious effect of CO on tissue respiration was confirmed by experimental data on gas exchange, change in blood gases, and arteriovenous difference and by the positive prophylactic effect of thiohine on tissue respiration following exposure to carbon monoxide. According to this investigation Cytochrome C merits attention as a means of pathogenetic therapy. - Authors' Abst.

124. Candura, F., Craveri, A., and Brasca, F.: Fibrinolysis in acute carbon monoxide poisoning. Experimental research. Folia Med. (Naples) 44:400-408 (May) 1961.

In experiments with rabbits, the authors studied the fibrinolytic behavior of the blood serum following acute or fatal poisoning with city-gas (CO content of 1.8-5%). A constant and significant increase in the content of fibrinolysin or plasmin, was found. This resulting increase in the fibrinolytic power of the blood may explain the occasional finding of a fluidity of the post-mortem state of the blood following a CO-poisoning death. No correlation was found between the rate of increase of fibrinolysis and the blood hemoglobin CO (HbCO) level. In view of the absence of any correlation, it is suggested by the authors that post-mortem blood fluidity--a finding which is not wholly characteristic of CO poisoning--might occur through nonspecific mechanisms which are brought into action by stress. - APCA 4255

124a. Candura, F., and Craveri, A.: Value and significance of fibrinolysis in experimental carbon monoxide intoxication. Rass. Med. Indust. 33:404-406 (May-Aug.) 1964.

Starting from the observation of the fluidity of the blood of subjects who have died from asphyxia, a study has been made on the behaviour of fibrinolysis in animals acutely intoxicated with carbon monoxide. The increase of fibrinolysis is found only in vivo, even in animals after removal of the adrenals. The removal of the spleen however, prevents the occurance of this process, so that two hypotheses may be advanced: the freeing of "ipossilienina" capable of orientig the blood coagulation towards hypocoagulability or the immission of splenin B in the circulation, a principle with a profibrinolytic activity. - Authors' Sum.

125. Carlo, S., and Bruno, P.: Biochemical and E.E.G. findings in some modern occupational poisonings. Riv. Sper. Freniat. 87:858-862 (June) 1963.

The literature on biochemical or E.E.G. findings of investigations of various industrial poisonings, is reviewed in this paper. Acute CO poisoning of rabbits resulted in cortical depression. Sharp reduction in the responsiveness of the electrical activity of the brain to intermittent photic stimulation was recorded immediately after the acute poisoning was induced. This condition could be reversed after a few days. Authors consider the many enzymic activities, such as dehydrogenase, flavine cyto-chrome-oxidase responsible for the changes in E.E.G. patterns. Authors draw the conclusion from the literature reviewed that only through the correlation of biochemical, histopathological and electrophysiological data, advances in industrial medicine can be made. They state that no data are, as yet, available concerning the activity of various parts of the central nervous system in industrial poisonings. - AGC

126. Chiodi, H., Dill, D.B., Consolazio, F., and Horvath, S.M.: Respiratory and circulatory responses to acute carbon monoxide poisoning. Amer. J. Physiol. 134:683-693 (Nov. 1) 1941.

No hyperpnea was observable during rest in either dogs or men when subjected to acute and severe CO poisoning. The CO_2 combining capacity was unchanged, the arterial pCO_2 was increased, and accordingly the pH was shifted toward the acid side.

In severe CO poisoning the respiratory center was depressed.

The cardiac output showed no more than slight increases with HbCO saturations ranging up to 30 per cent. From that level up to 50 per cent HbCO the cardiac output increased as much as one-half.

The direct action on the respiratory center of the acute hypoxemia produced by CO poisoning that is severe yet compatible with life is purely depressive in nature.

From the data given the oxygen tension in venous blood can be calculated for various levels of HbCO. - Authors' Sum.

127. Chornyak, J., and Sayers, R.R.: Studies in asphyxia. I. Neuropathology resulting from comparatively rapid carbon-monoxide asphyxia. Pub. Health Rep. 46:1523-1530 (June) 1931.

The chemical and pathological reaction of dogs to asphyxia by carbon monoxide and by atmospheres which are deficient in oxygen has been studied during the past two years by the United States Bureau of Mines. These studies have been conducted for the purpose of obtaining fundamental information on the response of the organism to asphyxial environment, with the particular viewpoint of devising a procedure for treating moribund cases of carbon-monoxide poisoning. It has been repeatedly observed that many of these cases have a fatal termination, even though respiration has been induced and the carbon monoxide removed from the blood.

The neuropathology produced in dogs by fatal exposures of 20 to 30 min. to 0.6% CO in air by volume was studied. Carbon monoxide produces a diffuse degenerative change throughout the entire brain. In this type of asphyxia the most serious effect appears to be edema of the dorsal motor nucleus of the vagus and the adjacent area in the medulla oblongata. - Authors Introduction Modified-AGC

128. De Boer, S., and Carroll, D.C.: The mechanism of the splenic reaction to general CO poisoning. J. Physiol. 59:312-332, 1924-1925.

When cats are poisoned with CO the spleen volume decreases. The B.P. falls if the rate of poisoning is rapid and either falls slightly or remains constant if the CO is slowly absorbed. In a few cases a sharp initial rise in B.P. takes place. The mechanism is very sensitive and responds to as low a percentage of COHb in the blood as 8 p.c.

The decrease in volume of the spleen is independent of the B.P. changes and is due to an active contraction of the splenic musculature.

CO poisoning does not cause any vaso-constriction in the spleen.

The excised surviving spleen does not contract, but dilates, when poisoned with CO. This effect is due to oxygen want.

The spleen does not contract in response to general CO poisoning of the animal when it is removed from nervous connection with the body either by nicotine poisoning or by decentralisation although in each case the spleen itself is poisoned with CO.

The contraction is not due to an effect on the adrenals or on the pituitary body.

The spleen perfused with oxygenated Ringer but in normal nervous communication with the body contracts when the animal is poisoned with CO.

The spleen of the decapitated cat contracts in response to general CO poisoning.

It is concluded that the spleen contracts owing to the effect of CO in producing an oxygen want in the spinal cord.

It is suggested that a function of the splenic contraction is to expel unpoisoned red cells into the blood and so reduce the proportion of COHb to HbO_2 in the general circulation. - Authors' Sum.

129. Douglas, T.A., Ledingham, I., Lawson, D.D., and Norman, J.N.: Carbon monoxide poisoning. A comparison between the efficiencies of oxygen at one atmosphere pressure, of oxygen at two atmospheres pressure and of 5% and 7% carbon dioxide in oxygen. Lancet, Jan. 13, 1962, pp. 68-69.

Two groups, each of ten dogs, were gassed with carbon monoxide mixtures until the carboxyhaemoglobin level was 70%. They were then resuscitated with pure oxygen at two atmospheres pressure, and the time taken for the carboxyhaemoglobin level to fall from 70 to 35% was noted.

The results were compared with the times for half-clearance of the blood when the same dogs, gassed in the same way, were resuscitated with oxygen at normal atmospheric pressure, or with 5% or 7% 'Carbogen' (carbon dioxide in oxygen).

Treatment with pure oxygen at a pressure of two atmosphere absolute was by far the most efficient. Next in order was 5% or 7% carbogen. Least effective was pure oxygen alone. -Authors' Sum.

130. Ehrich, W.E., Bellet, S., and Lewey, F.H.: Cardiac changes from CO poisoning. Amer. J. Med. Sc. 208:511-523, 1944.

All experiments were performed upon dogs. Acute CO poisoning was produced in some animals by inhalation of the gas and in others by intravenous introduction of erythrocytes saturated with CO; while chronic poisoning was effected by exposure to 0.01 vol. % CO for 5 3/4 hours daily over a period of 11 weeks. As a control, chronic anoxia was produced in other animals by exposure to an atmosphere containing only 10 vol. % O_2.

The electrocardiographic changes observed were inversion of the T wave, elevation of the R-T segment, atrioventricular dissociation, and A-V heart block. The morphologic changes included certain degenerative changes of individual muscle fibers, as well as hemorrhages and necroses of the myocardium. While the changes in the T wave and R-T segment and the degenerative changes appeared as early as at 40% COHb in acute experiments, or at 21% COHb or an equivalent O_2 deficiency in chronic exposure, heart block and myocardial hemorrhages and necroses were observed only when the COHb level exceeded 75% for 1 hour or longer.

It was noted that the electrocardiographic and morphologic changes of the heart in CO poisoning closely resemble those observed in anoxia due to other causes. Authors also give a brief review of the literature on cardiac changes. - Authors' Sum.

131. End, E., and Long, C.W.: Oxygen under pressure in carbon monoxide poisoning. J. Indust. Hyg. & Toxicol. 24:302-306 (Dec.) 1942.

Carbon monoxide causes tissue damage by producing anoxia. Our current methods of treatment are unable to correct this anoxia. Inhalation of oxygen under three atmospheres of pressure is capable of preventing such anoxia by causing solution of enough oxygen in the blood to provide for the needs of the tissues. Inhalation of oxygen under this pressure for several hours is safe. In experiments reported in this paper, guinea pigs and dogs poisoned with carbon monoxide were quickly restored to consciousness by inhaling oxygen under three atmospheres of pressure. This is taken to indicate that their anoxia had been corrected. Such treatment also accelerates elimination of carbon monoxide so that thirty minutes' treatment proved ample to remove most of the carbon monoxide from the animals bodies. Elimination curves for this and other types of treatment are given. It is proposed to introduce inhalation of oxygen under pressure in the treatment of human beings severely poisoned by carbon monoxide. - Authors' Sum.

132. Gorbatow, O. and Noro, L.: On acclimatization in connection with acute carbon monoxide poisoning. Acta Physiol. Scandinavic 15:77-87, 1948.

The authors have exposed rats and mice daily to carbon monoxide in contents of 0.25, 0.4, 0.5 and 1%. Their observations are as follows:

The test animals became acclimatized to carbon monoxide in contents of 0.25-0.5% and the tolerance against CO in 8-15 days increased 2-4 times its former value. In 1% CO only slight acclimatization was observed.

An intermission of several days in exposure diminished the tolerance. The longer the intermission was the more tolerance (got by acclimatization) the animal lost.

In connection with acclimatization polycythemia was observed which disappeared later. However, tolerance clearly increased without polycythemia.

No decrease of COHb was observed in connection with acclimatization.

The general condition of test animals became worse during "acclimatization". - Authors' Sum.

133. Haggard, H.W.: Studies in carbon monoxide asphyxia. I. The behavior of the heart. Amer. J. Physiol. 56:390-403, 1921.

Death under carbon monoxide asphyxia is due to failure of respiration. This is in the nature of a fatal apnoeavera. The anoxemia resulting from the formation of carboxyhemoglobin induces excessive breathing; and respiratory failure follows the excessive loss of CO_2. Oxygen deficiency caused by carbon monoxide, even in advanced asphyxia is not in itself sufficient to cause impairment of auriculo-ventricular conduction. Following respiratory failure, however, the increased anoxemia from this cause speedily results in the development of heart block through its various stages.

By restoring respiration and rapidly eliminating the carbon monoxide by means of inhalations of carbon dioxide and oxygen, cardiac conduction is restored to normal following the development of block.

The cardio-inhibitory center maintains its activity longer than does the respiratory center. This center is stimulated by the increased C_H which occurs during respiratory failure. From this there results a temporary cessation of auricular activity. This period of inhibition is prevented by the administration of atropine.

When respiratory failure is prevented by means of inhalations of 8 or 10 per cent carbon dioxide, the carbon monoxide combination with hemoglobin rises to an unusually high percentage without any evidence of impairment in a-v conduction. This indicates that there is no direct toxic action of carbon monoxide upon the cardiac conducting system.

Illuminating gas results in an earlier development of respiratory failure than does pure carbon monoxide in corresponding concentration.

Electrocardiographic records are given from two animals which differed from the rest in that one developed a transient period of alternation involving the R and T waves and the other presented, during the time of complete a-v block, a condition resembling auricular fibrillation or flutter. - Author's Conclusion

134. Jerzykowski, T., and Nowak, S.: The effect of acute carbon monoxide poisoning on riboflavin level in blood and tissues. ACTA Physiologica Polonica, 14:115-126, 1963.

Rabbits with acute carbon monoxide poisoning had riboflavin levels that were in muscles 25 percent lower and in blood 21.3 percent higher than in controls. The differences were statistically significant. No differences of riboflavin levels was demonstrated in the liver of poisoned rabbits.

The levels of riboflavin in liver and muscles were investigated also in rats before and after acute carbon monoxide poisoning, but no distinct differences similar to those described before were detected.

The authors suppose the changes recorded in rabbits to be due to a general effect of carbon monoxide poisoning, which causes riboflavin to become released from the muscles probably owing to protein decomposition, and to escape into blood.

The following average values of total riboflavin were recorded: in rabbits: blood 21 y%, muscles 199 y%, liver 960 y%; in rats: muscles 393 y%, and liver 1313 y%. - Authors' Sum.

135. Marchiaro, G., Margaria, E., Gaido, P.C., and Aquaro, G.: Acid-base equilibrium in experimental acute intoxication from carbon monoxide. Rass. Med. Indust. 33:452-453 (May-Aug.) 1964.

In dogs experimentally intoxicated with CO a progressive decrease has been found in the pH values of the blood accompanied by an increase of the pCO_2. The acidosis condition tends to correct partially during the successive stages of treatment. - Authors' Sum.

136. Pattono, R., Marchiaro, G., Capellaro, F., and Orione, G.: Dynamics of CO elimination under various conditions. Rass. Med. Indust. 33: 456-457 (May-Aug.) 1964.

The elimination of CO has been studied in experimental animals during various stages of intoxication. When animals were treated with clean air the carboxyhemoglobin dropped 40%. Treated with controlled pure oxygen the process was a much faster one. When having animals breathing simultaneously oxygen, air and hypothermal air up to 32° the progress of elimination was slowed down. - Authors' Sum.-AGC

137. Pecora, L., Vecchione, C., and Fati, S.: On the binding of carbon monoxide in the blood in acute and chronic carbon monoxide poisoning. Folia Med. 43:568-580 (June) 1960.

Experimental studies in vitro were made by the authors of the stability of the carbon monoxide linkage with the blood subsequent to acute or chronic poisoning. In acute poisoning a group of 12 rabbits were exposed on the 1st, 5th, 10th, and 20th days; in chronic poisoning a similar group of rabbits were exposed for 120 days with the carbon monoxide at a level of 100 ppm. For each type of poisoning the CO levels were determined for newly-drawn samples of blood and of samples which had been exposed to the air for varying periods. From results of these studies it was shown that the greater the number of acute poisonings, or the more prolonged the chronic poisoning, the less was the quantity of CO freed from the red cells or from the plasma after exposure to air. There was, therefore, a progressive increase in both the plasma and globulin carboxyemia. From these studies it is evident that in repeated poisonings CO is not only distributed in the blood in a different way compared with single poisonings, but also that links which are unlikely to be reversible are established both in the plasma and in the red blood cells. - APCA 4021

138. Pecora, L.: Ferrous therapy in acute carbon monoxide poisoning. Rass. Med. Indust. 33:352-353 (May-Aug.) 1964.

In experiments, rabbits poisoned with carbon monoxide showed hypochromic anemia, increased enzymatic erythrocytic activity, decreased iron in bone, muscle, liver, lung, and spleen tissue, and an increased urinary elimination of iron. On this basis, 62.5 mg of iron was injected intravenously into acutely poisoned humans. Symptomatology regressed rapidly as did the blood level of carboxyhemoglobin, demonstrating that in addition to producing a condition of asphyxia, carbon monoxide also exerts a true toxic action. - NASA 80284

139. Querci, M., Margaglia, F., Orione, G., and Acquaro, G.: Hemodynamic variations in experimental acute carbon monoxide poisoning. Rassegna di Medicina Industriale e di Igiene del Lavoro 33:454-455 (May-Aug.) 1964.

The authors have observed that the inhalation of CO by laboratory animals produces an increase in the cardiac frequency with a simultaneous increase in the systolic pressure which decreases progressively when the carboxyhemoglobinemia values reach about 10%. The marked progressive increase of the pressure of the pulmonary arteries is probably due not so much to the decrease of the alveolar tension of the oxygen but to the decrease of the oxygen in the blood. - Authors' Sum.

140. Ramsey, T.L., and Eilmann, H.J.: Carbon monoxide acute and chronic poisoning and experimental studies. J. Lab. & Clinical Med. 17: 415-427, 1931-1932.

Presented is a study of carbon monoxide from a standpoint of the method of its production, its affinity for hemoglobin, its action upon being respired, the percentages of blood saturation in varying lengths of time according to the concentration in the respired air, the symptoms and effect upon the body, possible methods of its elimination from the body, the production of chronic carbon monoxide poisoning, methods of treatment, the postmortem macroscopic appearances of the body following carbon monoxide deaths, some important medicolegal facts, a series of experiments on guinea pigs to ascertain its persistence in the body following exposure, and the histopathology of various tissues in animals dying, directly during exposure, and those killed and autopsied at varying periods later. - Authors' Sum.

141. Rubino, G.F.: Hemodynamic alterations during acute intoxication from carbon monoxide. Rass. Med. Ind. (Rome) 33:268-274 (May-Aug.) 1964.

In this paper the results are reported of research on the hemodynamic alterations observed during experimental intoxication from carbon monoxide (using air with a content of CO varying from 0.8% to 2.0%), and the subsequent revival of the dogs. An increase in the cardiac frequency was observed and a slight increase in the systemic pressure. The pressure of the pulmonary artery, however, increased as much as twice and even three times. A particular aspect of the autonomy of the coronary circulations is pointed out, and the hypothesis is advanced that the responsibility for the pathogenesis of chronic pulmonary heart lies not so much in the decreased alveolar O_2 tension as in the lessened O_2 content of the blood. - APCA 64-171

142. Spencer, T. D.: Effects of carbon monoxide on man and canaries. Ann. Occupat. Hyg. (London) 5:231-240 (Oct.-Dec.) 1962.

Since the scientific literature contained little information on the measuring of the effect of CO on canaries, and none since the refinement of measuring techniques which have occurred in the last decade or so, the author a few years ago carried out a series of tests of such effects. There are 3 major differences between the effects of CO on man and of those on the canary. The 1st is the difference in what can be measured. In man the gas produces headache, dizziness, and nausea but these symptoms cannot be assessed with any certainty in the canary. The time that the canary falls off the perch is the only measurement that can be made with any assurance. It is obvious that there is no equivalent to the walking or working man; all canaries are "resting." The 2nd is that a canary reaches a state of equilibrium with the CO it is breathing much more quickly than a man does. If the atmosphere contains enough CO to cause all canaries put in it to fall of their perches (i.e., more than 17.5 parts/10,000 parts of air), this fall will occur within 20 minutes and usually within 10. A resting man could be 4-5 hours in such a concentration before losing consciousness. At concentrations of more than 17.5 parts the canary would fall off its perch nearly always before a walking man had developed any symptoms of poisoning and always before a resting man had done so. It is this fact, of course, which has made the canary so valuable in rescue operations. The 3rd difference is 1 which does not appear to be widely known. It takes 2 or 3 times the concentration of CO to produce in a canary effects which can be considered as equivalent to those in man. The lowest concentration of CO which appeared to produce any effect whatever in a canary seemed, from those observations, to be 6 parts/10,000 parts. The lowest concentration that will make any canary fall off its perch is 12.5 parts; in man unconsciousness will occur in 4 or 5 parts. It has always been considered that the canary was more "sensitive" to CO than man. In man, hemoglobin has about 250 times the affinity for CO than it has for oxygen; in the canary this figure appears to be 110. In 1 sense of the word a canary is, therefore, not nearly as "sensitive" to CO as man. This fact is more than counterbalanced in CO of more than 20 parts by the speed at which the canary's blood comes into equilibrium with the atmosphere breathed. At the lower levels, and particularly in 12 parts/10,000 parts of CO or less, a canary will not only be useless but will be a dangerous cause of false confidence. - APCA 5389.

143. Takahashi, K.: II. Changes of the heart excitability, due to acute CO poisoning. Tohoku J. Expt. Med. (Sendai) 74:224-233 (July 25) 1961.

Changes of the heart excitability were observed on the electrocardiogram of dogs poisoned acutely by inhalation of CO gas. Due to inhalation of 0.05-1% CO gas for 60 min., a remarkable prolongation of refractory periods was observed in all animals and the elevation of resting threshold was seen in a few animals. The lowering of heart excitability was shown not only during gas inhalation but after its cessation. Then the strength interval curve shifted to the right. Due to inhalation of 2.5% CO gas for 15 min., the heart excitability was decreased slightly during inhalation but recovered quickly by inhalation of pure oxygen. Then the absolute refractory period was reduced. It required a definite time duration for which the carboxyhemoglobin (COHb) level was maintained at a certain high level, to produce the lowering of heart excitability. Lowering of the excitability continued and became severe after cessation of gas inhalation. The disturbances of heart muscles due to CO poisoning may be attributed to disturbances of myoglobin and/or cytochrome C. The reduction of the absolute refractory period was observed by the inhalation of 2.5% CO gas for 15 min. and this may be attributed to the compensatory function in the early stage of hypoxemia. - APCA 4465.

144. Yant, W.P., Chornyak, J., Schrenk, H.H., Patty, F.A., and Sayers, R.R.: VI. Blood chemistry of dogs after comparatively rapid carbon-monoxide asphyxia. In: Studies in Asphyxia. U.S. Treasury Dept., PHS, PHB No. 211, 1934, pp. 61.

Among dogs exposed to atmospheres which were depleted of oxygen at a rate which caused a progressive asphyxial condition simulating asphyxia resulting from exposure to approximately 0.6 percent carbon monoxide in air by volume, there was a marked hyperglycemia and hyperuricemia.

The nonprotein nitrogen and urea increased slightly. The total and preformed creatinine remained practically normal; the inorganic phosphorus increased.

There was an increase in the hydrogen-ion concentration, and a marked decrease in the carbon-dioxide capacity of the plasma and the carbon-dioxide content of the blood.

The oxygen saturation of the arterial blood at death ranged from 1.3 to 8 percent.

The blood counts showed no marked abnormalities. - Authors' Sum.

effect of chronic (long term and low) concentrations

145. Beck, H.G., and Fort, W.: Chronic carbon monoxide poisoning. Ann. Clin. Med. 3:437-443, 1924-1925.

Two case studies of chronic carbon monoxide poisoning are discussed in detail in this paper. Because of the manifold and protean character of the clinical manifestations, only a few of the more common symptoms could be given in this paper. The pallor of many patients resembled a high grade of anemia, as well as a group of symptoms are suggestive of anemia in the presence of a red cell count of over 5,000,000. This condition is of considerable diagnostic significance. There is no specific antidote for chronic carbon monoxide poisoning and treatment has to be symptomatic.

An English bull dog was named the victim in a third case study of carbon monoxide poisoning. The blood examination showed a hemoglobin of 95%, erythrocytes 5,120,000 and leukocytes 12,250. There were no morphological changes in the red cells. - AGC

146. Beck, H.G.: Slow carbon monoxide asphyxiation. A neglected clinical problem. J. A.M.A. 107:1025-1029 (July-Sept.) 1936.

A series of carefully studied cases of slow carbon monoxide asphyxiation has been studied.

The symptoms exhibited have been correlated with the pathologic lesions produced in experimental animals and found at autopsy.

The results establish the fact that slow carbon monoxide asphyxiation (anoxemia) produces a definite clinicopathologic entity despite views held to the contrary.

The symptoms arise predominantly from organs rich in blood supply, thus demanding much oxygen, such as the central nervous system and the heart muscles.

Owing to doubt and uncertainty as to the actual existence of the malady and a scant literature on the subject, the condition is not generally recognized by the profession and its importance has been underestimated.

Since there is no medicinal remedy when the organic changes have once developed, treatment must be directed toward its prevention by proper public health measures. - Author's Sum.

147. Burrell, G.A., Seibert, F.M., and Robertson, I.W.: Relative Effects of Carbon Monoxide on Small Animals. U.S. Bureau of Mines Technical Paper #62, 1914, 23 pp.

In testing for gas in mines small animals may be used repeatedly without danger of their being less susceptible to carbon-monoxide poisoning after many exposures than after the first, if they are allowed to recover between exposures.

Canaries are less resistant to carbon-monoxide poisoning than mice, chickens, rabbits, guinea pigs, or dogs. It is recommended that canaries be used whenever possible and that at least three of them be carried by an exploration party.

Men may display distress in the presence of proportions of carbon monoxide as small as 0.10 per cent, whereas small animals in the same atmosphere may show no signs of being affected. - Authors' Sum.

148. Campbell, J.A.: Hypertrophy of the heart in acclimatization to chronic carbon monoxide poisoning. J. Physiol. 77:8P-9P, 1933.

In the course of the post-mortem examinations of tar-cancer mice, some of which had been exposed for about 9 months to chronic carbon monoxide poisoning and others for the same period to oxygen at high pressure (60 p.c. atmos.) in the air, it was observed that the average weight of the hearts of the mice exposed to carbon monoxide was much greater than that of the mice exposed to high oxygen and also than that of the control mice. Only one of the controls and two of the mice exposed to high oxygen possessed hearts weighing more than 0.235 gm. Of the 19 mice exposed to carbon monoxide, 14 possessed hearts weighing between 0.235 and 0.340 g.; in 4 others the weights were between 0.200 and 0.235 g.; 0.435 g. was the weight of the heart in the remaining mouse. - Author's Abst.

149. Campbell, J.A.: Growth, fertility, etc. in animals during attempted acclimatization to carbon monoxide. Quart. J. Exper. Physiol. 24: 271-281, 1935.

Some mice and rabbits maintain their rate of growth when slowly acclimatized to about 0.3 per cent. of carbon monoxide in the inspired air. It is pointed out that man's ability to acclimatize gradually to the gas has never been properly tested, and, although not so resistant as certain animals appear to be, he probably possesses much greater resistance, to such gradual exposure, than has so far been suspected.

The heart of the mouse is often much hypertrophied during slow acclimatization, and this organ is regarded as playing a chief part in the powers to acclimatize.

The mouse appears to be more easily acclimatized to carbon monoxide than to low oxygen pressure in the air.

Mice after acclimatization to 0.30 per cent. carbon monoxide are not fertile; true acclimatization is thus not attained.

If carbon monoxide is consumed by living animals when breathing 0.30 per cent. of the gas, the consumption must be of a very low order, as is to be expected from Fenn and Cobb's results for frog's skeletal muscle exposed in vitro to 80 per cent. of the gas.

The carbon monoxide pressure in the tissues is less than half that in the inspired air. Oxygen pressures in the tissues are reduced to half the normal value in an acclimatized animal breathing 0.30 per cent. carbon monoxide. - Author's Sum.

150. Chernov, V.M. and Liberman, S.S.: Problem of combined action of carbon monoxide and benzene vapor. Farmakol. i. toksikol. 10:22, 1947.

Experiments were performed with mice to determine the combined toxic action of CO and benzene, such as might develop in those working in motor transport. The concentration, period of exposure and temperature of air in the vapor chambers were noted. It was found that neither CO alone nor benzene alone caused a very marked mortality at certain temperatures. But when animals were exposed to the 2 together the cumulative toxic effect was notable. A rise in temperature considerably increased the toxic action of benzene. The practical importance of these observations is great in view of the many cases of poisoning among those exposed to the 2 substances. - Kett.

151. Clark, R.T., Jr., Otis, A.B., and Leung, S.W.: Acclimatization of mice to carbon monoxide and low oxygen. Amer. J. Physiol. 159:564, 1949.

Mice were exposed to carbon monoxide in gradually increasing concentration from 0.03% to 0.15% over a period of 14 days, after which the animals were removed to room air for a day. They were then tested for tolerance to a simulated high altitude of 34,000 feet. Survival times of the mice previously acclimatized to CO were considerably longer than mice unacclimatized to CO. The converse of the above experiment was attempted by subjecting mice to an atmosphere containing oxygen in gradually decreasing amounts from 10% to 7% for a period of 14 days. The controls and experimentals were then exposed to an atmosphere containing 0.25% carbon monoxide. Survival times of the mice previously acclimatized to low oxygen were considerably longer than the mice unacclimatized to low oxygen. Blood studies were made on mice after acclimatization to carbon monoxide and low oxygen. In both cases the oxygen capacity increased about 60% above the controls, and the hematocrit 85%. The carbon dioxide capacity of the plasma was found to decrease for the mice acclimatized to low oxygen, but showed no change from controls for these animals acclimatized to carbon monoxide. The pH of the blood of mice acclimatized to carbon monoxide was found to be considerably higher than that of the mice acclimatized to low oxygen. The rate of oxygen consumption was the same the first few days of exposure to carbon monoxide and low oxygen as at the end.

152. Clark, R.T., Jr., and Otis, A.B.: Comparative studies on acclimatization of mice to carbon monoxide and to low oxygen. Amer. J. Physiol. 169:285-294, 1952.

Mice which have been acclimatized to concentrations of CO up to 0.15 per cent for 14 days can survive an acute exposure to 34,000 feet considerably longer than mice unacclimatized to CO. Mice which have been exposed to low O_2 for 14 days can survive in an atmosphere containing 0.25 per cent CO considerably longer than mice unacclimatized to low O_2. The oxygen capacity and hematocrit increased to about the same extent for the mice acclimatized to CO and low O_2. The oxygen capacity increased about 50 per cent above the controls, and the hematocrit 85 per cent. The CO_2 capacity of the plasma was found to decrease for the mice acclimatized to low O_2. Mice acclimatized to CO showed a higher CO_2 capacity than unacclimatized mice. The decrease in CO_2 capacity of the mice acclimatized to low O_2 was of the same magnitude as the decrease that other investigators have observed for human residents at high altitude. Hematocrit ratios and weight changes were measured during acclimatization and retro-acclimatization to CO and low O_2. The changes noted for the mice in CO and low O_2 were the same. The hematocrit values increased steadily during the acclimatization period. During the retro-acclimatization period the hematocrit remained at about the same high value for the first 8 days and then dropped rapidly to the normal level. The weights of the mice during acclimatization decreased rapidly during the first few days and then more slowly. About 35 per cent of the body weight was lost during the acclimatization period. During the retro-acclimatization period the weights rose rapidly for the first few days and reached the control level about the eighth day.

The average rate of oxygen consumption during the acclimatization period for mice in low O_2 was 3.1 cc/gm/hour; for mice in CO, 3.0 cc/gm/hour; and for mice in room air, 3.2 cc/gm/hour. - Authors' Sum.

153. Desoille, H., Truffert, L., Lebbe J., Boncour, R., and Girard-Wallon, C.: Experimental chronic carbon monoxide poisoning. Arch. Maladies Profess. Méd. Travail Sécurité Vol. 25, No. 7/8, pp. 389-392, 1964.

The sequence of experiments in regard to the problem of chronic carbon monoxide poisoning, often investigated but not yet finally solved, is described in this paper. Two experimental sequences with animals are discussed. 1. A constant carbon monoxide content was maintained in the atmospheric air for six hours daily, for five days per week. 2. Periodic carbon monoxide inhalations interchanged with periods of breathing in atmosphere clear of carbon monoxide. In experiment no. 1, no elevated CO-content of the blood was ascertained 48 hours after discontinuation of the CO influence of 250 to 450 ppm. Only changes in the electroencephalograph and in the blood serum could be ascertained. Certain acclimatization effects could be observed according to the authors. In the second experiment the animals were exposed to 2000 ppm carbon monoxide for one hour, four times daily. The considerably elevated CO-blood content was immediately reduced by breathing clean air. Also, after a rest period of two days, on Monday, no elevated CO-blood content was ascertained. These results correspond to earlier investigations of the authors with smokers. These investigations will be continued in view of the changes of the serum-protein in the blood. - AGC

154. Hinners, R.G.: Engineering the Chronic Exposure of Animals to Laboratory Produced Automobile-Exhaust. J. APCA 12:527-530 (Nov.) 1962.

In addition to studies involving direct exposure to urban atmospheres characterized by automotive emissions, the biological effects of exposure to controlled atmospheres where automobile exhaust is the sole pollutant must be identified, both to evaluate the importance of the known source and to define its comparative role in the presence of other contaminants and environmental factors. The laboratory facility at the Laidlaw Avenue annex to the Robert A. Taft Sanitary Engineering Center was established to initiate studies utilizing automobile emissions tailored to simulate realistically the conditions and daily changes of city air. An automobile engine is coupled to a dynamometer unit designed to produce exhaust and blowby according to an established "driving" pattern. The emissions are proportionally diluted with cleaned conditioned air under regulated pressure and fed to four dynamic flow irradiation chambers. The chambers are lighted by a composite of three types of fluorescent bulbs designed to simulate sunlight to intensity and spectral distribution. The dilution system provides non-irradiated or "raw" exhaust in a similar time-concentration pattern. A third line carries cleaned air at the same rate of flow. Four separate sets of conditions are to be maintained in the chambers, the variables of concentration, rate of flow, duration and intensity of light being subject to decision. These atmospheres are monitored with continuous recording instruments for CO, NO, NO_2, hydrocarbons and ozone on a rotational schedule. Periodic samples will be analyzed by wet chemistry to determine aldehydes, peroxyacetylnitrates (PAN), olefins and organic acids. Effluents from the 4 irradiation chambers along with their companion raw exhaust and cleaned air are ducted to 4 large tables, each supporting 24 animal exposure chambers. A single type of atmosphere supplies one group of 8 chambers/table. The locations are interlaced to balance distance from source. Animals under exposure will be tested for immediate responses and will be observed over their lifetime also to detect the development of chronic disease conditions. - Author's Abst.

155. Lewey, F.H., and Drabkin, D.L.: Experimental chronic carbon monoxide poisoning of dogs. Amer. J. Med. Sc. 208:502-511 (Oct.) 1944.

Dogs, exposed for 5½ hours per day, 6 days a week, over 11 weeks, to an atmosphere containing 0.01 vol. % CO, and reaching daily 20.1 ± 1.1% HbCO, showed a consistent disturbance of postural and position reflexes, and of gait.

Some of them showed a pathologic electrocardiogram, characteristic of anoxia, and necrosis of single heart muscle fibers.

Their central nervous systems showed, 3 months after termination of the experiment, histologic changes in the cortex and white matter of the cerebral hemispheres, in the globus pallidus and the brain stem. These alterations corresponded in type and localization to those found in acute CO poisoning, but were smaller, more scattered and less destructive. They followed in their arrangement the course of blood-vessels, the walls of which were damaged only occasionally.

One dog, in which the posterior coronary artery had been ligated 1 year prior to the exposure for a period of only 18 days to CO, showed the earliest and severest cardiac and cerebral changes of all animals observed. This result suggests that an inadequate functioning heart increases the general risk in CO poisoning, and may be responsible for a higher degree of brain damage.

Our findings indicate that chronic CO intoxication may occur in dogs at CO concentrations which have been regarded as being within the safety limits for man.

These experiments do not permit any conclusions as to the potential reactions of the human body to the same conditions. - Authors' Sum.

156. Malorny, G., Fodor, C., and Pomp, H.: Effect of low CO-concentrations on movement and reflexes. Arch. Experiment. Pathol. & Pharmacol. 246:23-24, 1963.

Tests were conducted with rats and mice for the determination of whether very low CO-concentrations contained in the atmosphere and inside working places can cause physical or psychological disturbances. The swimming performance of mice put into water and exposed for one hour to CO-concentrations of 0.03-0.05 Vol. % was much lower than the performance of control animals. The same slow performance was observed with animals put into water 2 hours after having been exposed to CO.

In testing spontaneous movements of mice the animals were placed into an air tight container into which alternating quantities of CO (160, 84 and 55 ppm) were piped in. After a 14 hour exposure the mice were put into a thread wheel and again exposed to CO for three hours.

In comparison with control animals running 1500 m in three hours, those exposed to 84 ppm CO were running 750 m and those exposed to 55 ppm 500 m during the same period of time.

The reaction of rats was tested after an exposure to 140-160 ppm CO. Tests were made 6 hours after exposure. Complete loss of reflexes was noted after 10 weeks. Since these disturbances remained for a long time after tests were completed, authors assume that the central nervous system had been permanently damaged. - From German-AGC

157. Murphy, S.D.: A review of effects on animals of exposure to auto exhaust and some of its components. J. APCA 14:303-308 (Aug.) 1964.

The studies conducted on animals exposed to experimental atmospheres polluted with automobile exhaust, produced and irradiated under conditions resembling those existing in urban communities are described. The series of experiments demonstrated that respiratory function and activity patterns of experimental animals are altered during brief exposure to irradiated air, auto exhaust mixtures at concentrations of total exhaust that were only 2-3 times those that occur in certain urban communities during max. periods of photochemical air pollution. The data indicated that the qualitative nature of the physiological response was dependent upon the relative concentrations of individual constituents with qualitatively different physiological actions. - APCA 6332

158. Musselman, N.P., Groff, W.A., Yevich, P.P., Wilinski, F.T., Weeks, M.H., and Oberst, F.W.: Continuous Exposure of Laboratory Animals to a Low Concentration of Carbon Monoxide. U. S. Army Chemical Warfare Labs., Army Chem. Center, Md., Jan. 1960, pp. 11. DDC AD 232115, and Aerospace Med. 30:524-529 (July) 1959.

The effects on dogs, rabbits, and rats of continuous exposure (24 hours a day, 7 days a week) to a low concentration (50 ppm) of carbon monoxide (CO). Three weeks after initial exposure, the hemoglobin, hematocrit, and red blood cell (RBC) counts of the dogs showed slight increases, which persisted throughout the remainder of the tests. The average per cent saturation of hemoglobin by CO was 7.3 for dogs, 3.2 for rabbits, and 1.8 for rats. Except for a small increase in the eosinophil count of the rats, no other blood changes were found. All tissues examined microscopically and macroscopically appeared similar to those of the controls. The exposed animals showed no significant differences as compared with the control animals in voluntary activity, behavior, body weight, ratio of heart weight to body weight, and electrocardiograms (EKG).

The absence of toxic signs and only slight blood changes in the dogs, rabbits, and rats used in the experiments indicate that no harmful effects result from continuous exposure of these animals to a concentration of 50 ppm of CO. - Authors' Abst.

159. Rozera, G., and Fati, S.: Acid and alkaline intra-erythrocytic and serous phosphatases in chronic carbon monoxide poisoning. Folia Med. 42:1204-1214 (Oct.) 1959.

During the course of laboratory-induced chronic carbon monoxide poisoning in rabbits, the authors studied the behavior of both serum and intra-erythrocytic acid and alkaline phosphatase activity. A very early and marked decrease in acid erythrocytic phosphatase activity was found and, as the poisoning progressed, there was a less marked decrease in erythrocyte alkaline phosphatase and in serum phosphatase. - APCA 3312

160. Schönbauer, L.: Air pollution and lung tumors. Wiener Klinische Wochenschrift 74:202-206 (March) 1963.

Increasing atmospheric pollution brings about an increase in diseases of the respiratory organs, in severity from bronchial catarrh to bronchial carcinoma. About 1912 the designation of a primary cancerous growth in the lungs was rare; presently, bronchial carcinoma has become a world-wide disease of considerable importance. Tobacco smoking has been said to be a very great, perhaps decisive cause of bronchial carcinoma. But apparently, also, the incidence depends upon the degree of industrialization of the region. Experimental studies on mice, which were exposed daily to dusts and to the exhaust gas of a car, disclosed in 44 out of 130 animals the presence of epithelial pulmonary tumors. This leads to the hypothesis that the exhaust gas of motor cars contribute to the genesis of lung tumors, at least in experiments on animals. It is essential that laws should be enacted against atmospheric pollution and that laboratories should be set up for its control. - APCA 6195

161. Walters, F.M.: Effects of carbon monoxide inhalation upon metabolism. Amer. J. Physiol. 80:140-149, 1927.

Carbon monoxide depresses the rate of metabolism, the degree of depression varying directly with the degree of saturation.

There is a lowering of body temperature that corresponds closely with the slowing of the metabolic rate.

The breathing of carbon monoxide concentrations of from 0.02 to 0.05 per cent for short periods (1 to 2 hours) has little if any effect upon the rate of metabolism of the rat, but for long periods (4 to 6 hours) it depresses the rate in individual cases.

Concentrations above 0.05 per cent have marked effects in depressing the rate even for short periods of exposure.

There is a correlation between the fall in the metabolic rate and the symptoms of carbon monoxide poisoning. - Author's Conclusion

162. Wilks, S.S., Tomashefski, J.F., and Clark, R.T., Jr.: Physiological effects of chronic exposure to carbon monoxide. J. Appl. Physiol. 14:305-310 (May) 1959.

A group of 7 dogs was given a daily 6-8 hour exposure to CO levels of 0.08 to 0.10% for a period of 36 weeks and their tolerance to CO was compared with that of normal dogs, altitude-acclimatized dogs, and dogs transfused with blood from normal dogs. The observed increased tolerance to CO was attributed primarily to the increase in concentration of the hemoglobin pigments in the blood. With this increased hemoglobin there was a greater reserve of the pigment for O_2 transport at a given concentration level of HbCO (carboxyhemoglobin). There was no evidence of factors, other than hematologic, which increased the tolerance of the dogs to CO. Animals subjected to other hypoxic stress such as altitude, or normal animals transfused with normal blood to increase the hematocrit level, showed increased tolerance similar to that accomplished by chronic exposure to low CO levels. - APCA 2643

163. Yant, W.P., Patty, F.A., Schrenk, H.H., and Berger, L.B.: The response of Japanese waltzing mice and canaries to carbon monoxide and to atmospheres deficient in oxygen. US BM RI 3040, Oct. 1930, pp. 12.

The response of Japanese waltzing mice to carbon monoxide and to atmospheres deficient in oxygen was determined, and a comparison made with the response of canaries. Because of their almost incessant activity, it was thought that the waltzing mice would respond more quickly than canaries and ordinary white mice to carbon monoxide and possibly atmospheres deficient in oxygen, and thus be more satisfactory than the latter animals for detecting air contamination that is harmful to man. A comparison of the response of these animals was made and the results correlated with the response of man.

The sensitivity of ordinary white mice, canaries, and waltzing mice to concentrations of carbon monoxide ranging from 0.10 to 0.25 per cent, increases in the order named.

Although waltzing mice appear to be slightly more sensitive to atmospheres deficient in oxygen than canaries and the latter slightly more sensitive than man, the margin of time between serious response of man and observable response of these animals is not wide enough for either canaries or waltzing mice to be of practical use for avoiding harmful exposure of man. - Authors' Sum.

Humans

effect of acute (short term and severe) concentrations

164. Abe, M., and Hara Y.: A case on an apallic syndrome as observed after an acute carbon monoxide toxicosis. Fukuoka Acta Med. 54:1057-1061 (Sept.) 1963.

This report is concerned with an apallic syndrome observed after a carbon monoxide poisoning with an acute course. The patient was a 42-year old woman. Her husband found her in the state of unconsciousness in the living room who apparently fell down due to a carbon monoxide toxicosis. She gradually regained her consciousness but was noticed somewhat different from what she was before the illness; she was expressionless and more silent.

It was ten days after the accident that the patient began to lose increasingly her spontaneity to such an extent that she ate only when she was spoon-fed; she never changed her position on the bed unless otherwise helped, and she showed no verbal response when questioned but gave only slight nodds.

For about a month and a half from the onset, the patient was in a full state of apallic syndrome. However, the patient then began to improve gradually and became able to smile and respond to some simple questions on the 100th day from the onset. At the examination on the 110th day, she was able to state her name, age and birth place, etc.

The patient is still under hospital observation. At present various clinical examinations have been showing no particular change.

Histological considerations have been also done of the brain in carbon monoxide toxicoses along with reference materials in this field. - Authors' Abst. Modified-AGC

165. Abt, I.A., and Witt, D.B.: A case of carbon monoxide poisoning in a child. Med. Clin. North America 5:1645-1651, 1922.

Acute carbon monoxide poisoning of a five year old boy who suffered total blindness, is described in this paper. The effect of CO poisoning on the blood and on various tissues and organs, particularly on the nervous structures, is discussed. Possibility of permanent blindness, assumed to be due to small hemorrhages or areas of softening in the visual centers, is outlined.

Authors review some of the hypotheses of other investigators in regard to the pathological changes produced by CO. Hemorrhages in the brain, degenerations, and optic thalmus, thrombosis, and areas of softening in the central nervous tissue and scattered small hemorrhages and intense hyperemia of all the body organs may occur as consequences to this type of poisoning. - AGC

166. Adler, A.: Disintegration and restoration of optic recognition in visual agnosia. Arch. Neurol. Psychiat. 51:243-259, 1944.

A case of visual agnosia in a woman aged 22 has been described, the course of the illness having been followed from the first day until the condition became stationary. The patient is 1 of the 2 persons in whom permanent lesions of the brain were produced, probably by carbon monoxide fumes, in a fire disaster at a night club on Nov. 28, 1942.

The fundamental disturbance consists of the patient's inability to perceive the whole, the Gestalt, visually. Only parts of the whole are perceived, and their correct relation is not recognized. This results in an inability to read, to copy letters and geometric figures and to recognize pictures or objects on short exposure. Writing is unimpaired.

Owing to the patient's intelligence and insight into her disability, it was possible to identify an additional disturbance in the nature of a perserveration of visual attention and optic impressions. Preceeding optic impressions superimpose themselves on subsequent ones, so that proper perception and recognition are interferred with. This symptom is of the same category as psychomotor perseveration and perseveration of speech and writing.

According to Lissauer's first description, such a condition belongs to the "apperceptive" type of visual agnosia, since there is a primary disturbance of optic perception. In this patient the disturbance is clearcut to an unusual degree. The identity of the mechanism exhibited by this patient in each of the disorders of visual performance makes it unlikely that the various symptoms of optic agnosia have a separate localizing significance.

Compensatory efforts to build up new methods of visual recognition should be encouraged. Constant practice is necessary, since such a patient is likely to distort and to forget what he has learned. - Author's Sum.

167. **Arena, J.M.: Carbon Monoxide: Report from The Duke University Poison Control Center. North Carolina Med. J. 24:28-29 (Jan.) 1963.**

This short paper summarizes the effect of CO poisoning on the health of man and advises on respective treatments. There is also a description of symptoms, in relation to percentage of CO in the atmosphere, duration of exposure and saturation of the blood. - AGC

168. Beghe, R.: Experiences in the treatment of acute carbon monoxide poisoning. Rass. Med. Indust. 33:337-351 (May-Aug.) 1964.

Experiences with 16 cases of acute carbon monoxide poisoning are presented, which were treated in artificial-respiration wards of Rome hospitals. The cases are clinically subdivided into three groups according to the degree of nervous, cardiovascular, and respiratory dysfunction. A review is included of the therapeutic procedures used during respiratory resuscitation (oxygen therapy), cardiovascular resuscitation, and drug therapy (vitamin C, hexaphosphene, cocarboxylases). Antibiotics are also administered to carbon-monoxide poisoned patients in order to prevent the frequently occurring complication of respiratory infection. It is advocated that departments be set up in hospitals to handle emergency treatment of carbon monoxide poisoning. - NASA 80283

169. Belza, J.: Electrocardiographic changes following acute carbon monoxide poisoning. Inaugural-Dissertation for the Degree of Doctor of Medicine. P.G. Keller, Winterthur, Switzerland, 1955, pp. 39.

The aim of this dissertation is to present the effect of acute carbon monoxide poisoning on the heart. The damaging influence on the myocardium as reflected in the clinical picture and electrocardiogram during the past ten years at the Medical Clinic of the University of Zürich, has been studied in particular. Frequency of pathological changes in the ECG following acute CO poisoning are discussed, and an attempt has been made to estimate the relation of the age factor to the speed of improvement of electrocardiographic findings. The most recent literature related to this problem is also reviewed. - Author's Sum. Modified-AGC

170. Bokonjic, N.: Stagnant Anoxia and Carbon Monoxide Poisoning. A Clinical and Electroencephologographic Study in Humans. Electroencephology & Clinical Neurophysiol., 1963, Suppl. 21, 102 pp.

A detailed description and comparison of clinical and electroencephalographic symptoms in humans suffering from acute anoxia due to strangulation and carbon monoxide poisoning is provieded in this publication. The important differences of these two types of anoxia are clinical and electroencephalographic syndromes which require differential prognosis. The association established between duration of unconsciousness and recovery prospects, and clarification of the influence of age and cardiovascular failure on the final outcome, are of particular prognostic value. - AGC

171. Borman, M.C.: Carbon monoxid poisoning. Mental and neurological changes in a case of acute carbon monoxid poisoning with partial recovery. Amer. J. Psychiatry 6:135-143, 1926.

A case of accidental carbon monoxid poisoning is reported in which the patient showed evidence of wide-spread central nervous system changes from which there was apparent recovery, followed again by numerous mental and neurological disturbances with ultimate recovery, except for the mental state.

The chemical alterations in the blood and clinical tests thereof in carbon monoxid poisoning are mentioned.

The anatomical changes in the central nervous system following carbon monoxid poisoning are discussed together with the various explanations offered for their occurrence. - Author's Sum.

172. Burck, H-C., and Portwich, F.: Acute renal failure after severe CO intoxication. Frankfurter Zeitschrift für Pathologie 73:520-534, 1964.

Symptomology, clinical course and pathologic-anatomic findings 14 days after severe CO poisoning of a woman, who at death, showed symptoms of acute renal failures are discussed. Since acute renal failure as consequences of CO poisoning are rare and due to anatomical findings, and other pathogenic factors, the shock syndrom had to be considered primarily. Two types of cell changes were noted in the tubules: vacuolation of the large epithelia and flattening of the epithelio, indicating the severity of damage. Authors discuss their own concept on the origin of the dilation of the tubules. - From German-AGC

173. Chalupa, B.: Disorders of memory in acute carbon monoxide intoxications. Pracovni Lekar. (Prague) 12:331-336, 1960.

The author presents an account of experimental examinations of the memory in a group of 44 persons who had recently suffered from acute CO intoxication. The average age was 35.6 yrs. The following methods were used: repeating 20 separate words, recognition of same material with control items, or repeating 30 verbal pairs having some relationships as to their content. The disturbances of memory manifested themselves by an affection of logic memory and difficult differentiation when attempting to recognize; mechanical memory was relatively intact. When evaluating the results in individual persons examined pathological changes of memory structure were revealed in 26 (59.1%). These findings were most frequent in a group of accidental acute and subacute CO intoxications (78.6%) though loss of consciousness was noted in only 21.6%. In suicidal CO intoxications, which in all instances were associated with loss of consciousness, pathological deviations were found in 54.4%. Differences in the affection are explained by the different conditions of exposure and the different methods of treatment of the patients investigated. In addition to concentration of CO, the time of exposure must be taken into account, this being particularly important in industrial and accidental CO intoxication where frequently protracted acute and subacute exposures with pathological findings occur though they are not associated with loss of consciousness. A comparison with COHb levels on admission revealed in 22 patients a positive correlation with the reduction of logical memory and with some indicators in the experiments on recognition. At COHb levels up to 29.9% disorders of memory were found in 33.3% at levels of 30-78%, in 61.5% of all cases. Repeated examinations after intoxication had subsided showed that logical memory and recognition had returned to normal and mechanical memory remained on the same level. From the present work some practical suggestions can be drawn for the prevention and assessing of toxic changes of the central nervous system after acute CO poisoning. - APCA 4835.

174. Ciocatto, E., and Pattono, R.: Organization of an artifical respiration center: Therapy of acute carbon monoxide poisoning. Rass. Med. Indust. 33:330-333 (May-Aug.) 1964.

The emergency treatment of carbon monoxide poisoning and other types of poisoning is generally relatively simple to carry out, but is handicapped in practice by organizational difficulties. A brief outline is given of the different problems regarding the medical staff and auxillaries, the emergency wards and equipment, and the transportation of poisoned subjects. All these points are of basic importance for the organizational function of an artificial respiration and cardiovascular center in a big industrial town. - NASA 80281

175. Colvin, L.T.: Electrocardiographic changes in a case of severe carbon monoxide poisoning. Amer. Heart J. 3:484-488, 1927-1928.

The points of interest in this case seem to be:

The electrocardiographic changes due apparently in the main to asphyxia, but possibly in some degree to the action of benzol, were such as to suggest damage below the division of the His bundle instead of at the A-V node.

These changes, suggesting damage to the ventricular muscle, disappeared rapidly and completely.

The supposition that if such damage may be done to a presumably healthy heart, an already impaired myocardium might, under similar conditions, suffer irreparably. - Author's Sum.

176. Courville, C.B.: Forensic neuropathology. XI. The asphyxiant gases. J. Forensic Sc. 9:19-46 (Jan.) 1964.

Noxious gases or vapors which produce untoward manifestations in man may be divided into the direct asphyxiants, whose toxic effects are due mainly to replacement of oxygen, and the indirect asphyxiants, whose toxic effects result from absorption of poison through the air passages. There are three types of direct asphyxiants: simple asphyxiants (smoke, fumes, and inert gases), chemical asphyxiants (carbon monoxide and cyanide gas), and central depressants (the anesthetic gases).

The primary effect of the simple asphyxiants is the exclusion of oxygen from the lungs. The chemical asphyxiants produce anoxia either by preventing the transportation of oxygen in the blood stream or by interfering with its utilization by the nerve cells of the brain. The central depressants produce anoxia by direct narcotic action on the cortex and basal ganglia, or by the precipitation of cerebral or respiratory failure and superimposition of other types of anoxia.

The indirect asphyxiants are divided into the industrial gases and the war gases. The most common industrial gases are hydrogen sulfide, sulfur dioxide, and ammonia.

In acute asphyxiation (survival up to two weeks), the brain is severely congested, with focal hemorrhages in the leptomeninges and white matter. Distention of the small blood vessels, perivascular hemorrhages and acute changes in the nerve cells occur. The parenchymatous elements and the Purkinje cells may also show acute change. Focal or laminar necrosis of the cortex and central necrosis of the basal ganglia are often associated with proliferation of the endothelium of the small blood vessels.

In the subacute stage (two to six weeks), a variety of cerebral lesions develop. Congestion may be present and focal cortical and subcortical softening may be seen. The cerebral cortex may have a diffuse granular appearance or may show a thin yellow zone of necrosis. Usually, softening of some portion of the basal ganglia will be found. Patchy, focal, laminar or subtotal necrosis occur in the cerebral cortex, with changes in the astrocytes and microglia, and proliferation of the vascular endothelium. The arterioles of the lenticular nucleus may contain rings of calcium or iron. The unmyelinated cortical nerve fibers, the myclinated sheaths of the corticofugal nerve fibers, and the white matter may show degenerative changes. The Purkinje cells may be changed and reduced in number. Deterioration of the granule cell layer may also occur.

The residuals of severe anoxia may be only minor, diffuse leptomeningeal thickening and cortical nerve cell loss, or they may be irregular cortical atrophy, cyst formation due to focal softenings, and central softening and demyelination. Microscopically, the cytological alterations observed in the subacute stage are present, as are iron deposits in the nerve cells. - Author's Sum.

177. **Del Vecchio, V., D'Arca, S., and Talenti, M.: Carbon monoxide intoxication and carbon monoxide in the atmosphere in Rome. Nuovi Ann. d'Igiene e Microbiol. 7:81-102, 1956.**

The 1st part of this article discusses the origin of CO contamination of the atmosphere of towns, the pathogenesis of CO poisoning, the relation between symptoms and concentrations of carboxyhemoglobin (COHb) and the atmospheric concentrations estimated by investigators in various cities of the world. The chief source of CO in urban surroundings is the presence of escape gases from motor vehicles, estimated in proportions varying from 3-14%, depending on the nature of the fuel, the cylinder performance, traffic congestion, confined spaces, etc. The affinity of CO for hemoglobin is 210 times greater than that of O_2, so that only small amounts of CO are necessary to immobilize significant amounts of hemogolbin with resulting decrease of O_2 transport by red blood corpuscles, leading to anoxemia and asphyxia. CO also binds respiratory ferments, interfering seriously with the oxidation-reduction mechanism, thus adding to its asphyxiant action the inhibition of respiratory tissue activation. Its toxic action is related essentially to the concentration of COHb. A table is given showing the correlation between the concentration of CO and O_2 in inspired air, the duration of exposure and the condition of pulmonary ventilation. Thus, for example, if a man with pulmonary ventilation of 9.5l./min. is exposed for 2 hours to 0.03% CO, the % of COHb in the blood reaches 15.6; in 3 hours it reaches 20. The coefficient of COHb/Hb indicates the % of Hb effectively transformed into COHb. In man, the lethal index is 0.66, i.e., death takes place when 2/3 of Hb is fixed. In a normal person at rest, 10% of COHb causes no symptoms, 20% slight headache, 32% headache, irritability and vertigo, 50% mental confusion and syncope, 66% unconsciousness and death, if prolonged. In the 2nd part of the article, the authors describe their own investigation of the CO concentration in the air of Rome from Nov. 1954-Oct. 1955, in various zones, at different times and in varying weather conditions, using Drager's apparatus with I_2O_5 as the colorimetric agent. The maximum concentration (0.015%) occurred in the Traforo del Quirinale in cloudy weather during intense traffic. While this is not likely to cause appreciable intoxication in the adult pursuring his ordinary avocations, individuals doing heavy work for 1-1/2 hours may experience initial symptoms, and in those spending a great part of their life in places where CO is constantly present may undergo some disturbance which may be aggravated by atmospheric contaminants. - Kett.

178. Francois, R.Ch., and Bertin, M.: Statistical study of the incidence of certain clinical signs during the course of acute carbon monoxide poisoning, and their immediate prognostical value (on 4952 observations of acute intoxication). Rass. Med. Indust. 33:380-391 (May-Aug.) 1964.

A statistical analysis is made on 4952 cases of acute carbon monoxide poisoning that were observed over a 4-year period. The incidence of the following clinical manifestations, which may be of value for immediate prognosis, are outlined: state of consciousness; neurological, mental, respiratory, and cardiovascular symptoms; face color (cyanosis); loss of urine; digestive and abdominal disorders; and hyperthermia. - NASA 80286

179. Henderson, Y.: Carbon monoxid poisoning. J. AMA 67:580-583 (Aug. 19) 1916.

Carbon monoxid is a physiologically harmless gas, except in its affinity for hemoglobin. Its toxic effects are wholly due to the inability of the blood combined with carbon monoxid to transport oxygen to the tissues.

Carbon monoxid does not form a permanent compound with hemoglobin. In the presence of excess oxygen, or even of pure air, carbon monoxid is rapidly given off and the oxygen carrying power of the hemoglobin is restored.

The continuance of coma, the subsequent tissue degenerations, and death after several days, resulting from carbon monoxid poisoning, are not due to retention of the gas, but are the results of injury to the brain and other organs by the insufficiency of oxygen supplied to them by the blood while the patient was breathing the gas.

There is no reason to believe that either bleeding or transfusion of blood is beneficial. They are more likely to be harmful.

Fresh air--with oxygen inhalation for a short time as early as possible--symptomatic treatment, and good nursing are the only measures to be recommended. Practically the die is already cast for death, permanent defects, or complete recovery at the moment when the patient is brought out of the asphyxial atmosphere.

It is just possible theoretically that alkali therapy may be beneficial in combating the acidosis induced by asphyxia. - Author's Sum.

180. Hundreds of motorists are killed by carbon monoxide. Public Health (Johannesburg) 63:30,32 (Sept.) 1963

In this article it is stated that many victims of death from carbon monoxide fumes are included in that group of persons dying from injuries sustained in car accidents commonly attributed to driver fatigue, drowsiness, or inattention. The charge is usually phrased as "failure to drive in a careful and prudent manner." A research project on deaths and injuries from CO, undertaken by a near-victim of the gas, revealed that neither the auto insurance companies nor the safety organizations had any statistical breakdown of numbers of deaths or accidents from this cause. But he also found that his own experience was not unique. Incidence in Canada and the U. S. of deaths from CO in automobiles are cited including 1 where the medical examiner judged that the driver in a fatal accident may have breathed the gas coming into his car from vehicles ahead of himself in the heavy traffic since blood tests indicated a CO saturation 35%. Individuals respond in various ways to CO, sometimes acting drunk or hilarious. The author suggests that the blood of such drivers be tested for both alcohol and CO content. Such tests may well save many lives. Regular checks of cars, for corrosion of the muffler and tail pipe, should be made and the driver should be sure that the car trunk closes tightly. When following another car within 60 feet the car ventilator should be closed. The ventilators should also be closed in heavy traffic, in tunnels, and when parked behind a car with the motor running. It should be a policy also never to sit, for any length of time, in a parked car with the motor running and the windows closed. APCA 6095.

181. Jackson, R.C., Bunker, N.V., Elder, W.J., and O'Connor, P.J.: Case of carbon-monoxide poisoning with complications. Successful treatment with an artificial kidney. British Med. J. Nov. 28, 1959, pp. 1130-1134.

A case is described of carbon monoxide poisoning with the following complications--skeletal-muscle necrosis, probable myocardial necrosis, acute renal failure, mental changes, and a radiculomyelitis of L 2-5.

The details of conservative management and haemodialysis (twice) by a Kolff twin-coil artificial kidney are given. The literature concerning muscle necrosis and renal failure, with the neurological sequelae, is reviewed. -Authors' Sum.

182. Johnson, D.M.: Killer on our highway. Good Housekeeping, June 1961, pp. 49 and 146-148.

This is a report of auto accidents fatal or near fatal possibly caused by the inhalation of CO. Author relates her own experience of CO asphyxiation, and describes the symptoms before she was overcome by CO fumes and crashed into another automobile. When she felt a strong sensation of drowsiness she wanted to pull off the road but was unable to see the side due to, as she found out later, the narrowing of the field of vision caused by the CO. In being overpowered by the drowsiness she lost judgement, control and consciousness, due to the fact that the inhaled lethal CO combines more than 200 times faster with the blood than oxygen. Thus the saturated blood cannot absorb enough life-giving oxygen. Deprived of oxygen the brain is affected sometimes severely and sometimes permanently. Author in quoting several case histories makes a plea for more research. Blood tests which are made routinely for the presence of alcohol, should be done just as routinely for the presence of CO in accident cases. Only the city of Philadelphia is doing these tests routinely when someone dies in a wreck. Philadelphia's medical examiner states that an appreciable percentage of drivers who die in automobile accidents have significant levels of CO in their blood. Author cautions driver to be aware that CO is odorless, to keep the car in good running condition and well ventilated - AGC

183. McBay, A.J.: Carbon monoxide poisoning. New England J. Med. 272:252-253 (Feb. 4) 1965.

Medicolegal problems in regard to death by carbon monoxide are discussed. Author states that the most puzzling cases are those produced by motor-vehicle exhaust fumes. About half of the fatal poisonings in the U.S. are attributed to CO, and many chronic sublethal poisonings by this gas are unrecognized. Exhaust of the gasoline engine may produce up to 7% CO. Exhaust of an automobile will saturate the interior of a small garage in 15 to 30 minutes with a lethal amount of CO. The affinity of CO for hemoglobin is 200-300 times greater than that of oxygen. Fatal poisoning may occur with a blood saturation of 30 or 40% of CO. Symptoms are not striking enough to make diagnosis easy. The much discussed pink color of the skin is rarely seen and the only valid test is the determination of the amount of CO in the blood. -AGC.

184. McConnell, J.W., and Spiller, W.G.: A clinicopathologic study of carbon monoxid poisoning. J. AMA 59:2122-2126 (Dec. 14) 1912.

Authors cite actual cases of acute carbon monoxid poisoning and the sequela thereof.

Authors divide poisoning by CO into three classes: acute poisoning, chronic poisoning and the third class is designed as relapsing CO poisoning a term used to indicate the conditions of those who, having apparently recovered from the initial effect of the poison, develop after a period of fair health a grave type of symptoms leading to death.

The special clinical interest in case study described lies in the time which elapsed between the initial poisoning and the development of the grave symptoms, in the bilaterality of the motor symptoms, in the intense spasticity present and in the absence of distinct vasomotor or trophic symptoms. - AGC

185. Mant, A.K.: Accidental carbon monoxide poisoning: A review of 100 consecutive cases. Medico-Legal J. 28:30-39, 1960.

One hundred consecutive deaths following the accidental exposure to carbon monoxide from miscellaneous sources have been analysed. The increasing number of poisonings amongst the elderly and the infirm has been demonstrated. The comparative ease with which accidental carbon monoxide poisoning may be missed, expecially where the source is not the simple escape of coal gas, has been shown, and emphasis has been laid upon the rapidity with which a fatal concentration of carbon monoxide may be built up in a poorly ventilated space when only a small amount of fuel is burnt.

Some of the new safety devices which are being developed to exclude many of the dangers of accidental poisoning have been mentioned. - Author's Sum.

186. Meigs, J.W., and Hughes, J.P.W.: Acute carbon monoxide poisoning: An analysis of one hundred five cases. Arch. Indust. Hyg. & Occupat. Med. 6:344-356 (Oct.) 1952.

An analysis is presented of findings in 105 patients admitted to the Grace - New Haven Community Hospital, Conn. between Jan. 1, 1920 and Dec. 31, 1948, with a diagnosis of acute carbon monoxide poisoning. A number of manifestations previously considered unusual were shown to be common in this series, namely, skin lesions, transient respiratory findings, excessive sweating, liver enlargement, localized pain or soreness, and localized edema. All these signs except pain or soreness and edema were shown to correlate statistically with severity of poisoning, as did several others including temperature of 102°F or higher, respiratory rate of 30/min or higher, and leucocyte count of 18,000/cc or higher. Several manifestations which were almost as common in patients with mild as with severe poisoning, were thought to be precipitated by responses of the automatic nervous system and the extent of response to be a function of the individual more than of the degree of intoxication. The signs which correlate with severity of poisoning may be manifestations of direct hypoxic injury to the oxygen-sensitive cells of the brain, as well as stimulation of the pituitary-adrenal mechanisms. - LC

187. Molfino, F., and Zannini, D.: On the treatment of acute carbon monoxide poisoning with oxygen therapy in a pressure chamber. Rass. Med. Indust. 33:334-336 (May-Aug.) 1964.

Three cases of carbon monoxide poisoning were treated with pure oxygen in a pressure chamber. This method not only provides good tissue oxygenation, but as regards carboxhemoglobinemia, 50% desaturation is attained in about half the time required to reach the same reduction with oxygen at normal pressure. - NASA 80282

188. Neubuerger, K.T., and Clarke, E.R.: Subacute carbon monoxide poisoning with cerebral myelinopathy and multiple myocardial necroses. Rocky Mountain Med. J. 42:29-35 (Jan.) 1945.

A case of subacute CO poisoning in a 19-year-old girl is reported. The condition led to death after thirteen days. Autopsy revealed cerebral myelinopathy and myocardial necrosis. The pathogenesis of these lesions is discussed. The significance of a low concentration of CO together with high atmospheric temperature in the present case is emphasized. - Authors' Sum.

189. Nicloux, M.: Acute carbon monoxide poisoning. J. AMA 77:1289 (Oct. 15) 1921.

Author emphasizes that the blood corpuscles even saturated with carbon monoxide are not devitalized at all, but are ready to resume functioning with a little aid, that is, when supplied with oxygen.

In a case described, seventy-five minutes after the poisoning, and after 650 liters of oxygen had been administered by the pulmotor, the blood still contained 9.08 per cent. carbon monoxide, showing that 41.3 per cent. of the hemoglobin was saturated with it. The oxygen was pushed, and in about an hour this percentage was only 25.4, and four hours later, 8.3. The survival of this patient after apparent death for twenty-five minutes shows that even 9.08 per cent. of carbon monoxide in the blood is not fatal. In the cases on record in which death occurred with poisoning of 0.1, 0.3 or even 0.4, author is convinced that some other factor than this poison was responsible for the fatality. The slightest movement is liable to bring on vertigo and loss of consciousness. This occurred twice in this case, the man saying he felt well and wanted to go home, and becoming unconscious when he started to get up. The pulmotor had been used beginning five minutes after apparent death which kept up for twenty minutes longer. About 650 liters of oxygen had been used and more was given in the hospital, for twenty minutes each hour, to a total of 1,500 liters. The headache and vertigo disappeared after the first inhalation.

190. Noro, L.: Carbon monoxide poisoning. Nord. med. 26:771-6, 1945.

The author describes the clinical picture and pathogenesis of CO poisoning and the existence of the poisoning in drivers of motor cars operated by charcoal gas in Finland. Of the 5,000 drivers, who were questioned, symptoms of CO poisoning were found in 67.5% of the cases. The symptoms of acute poisoning were complained of by 3,069; symptoms of chronic poisoning, by 2,506 drivers. In 530 cases the poisoning had caused inability to work. In Finland at present, CO poisoning is the most common occupational disease. - Kett.

191. Paris, J.: Study of the "excitation-duration" curves after occupational acute CO poisoning. (French) Rass. Med. Indust. 33: 275-291 (May-Aug.) 1964.

The author has made a study of the neuromuscular excitation curves after acute occupational intoxication from CO with an electronic rheotome. These curves are featured by hypoexcitability of the nerve with corresponding inversion of the nerve-muscle excitability ratio. The inversion of this proportion seems to render objective the subjective clinical syndrome of muscular asthenia and great weakness of the lower limbs that is observed after acute carbon monoxide poisoning. - Author's Sum.

192. Parmeggiani, L., Cambruzzi, S., and Colombo, G.: Carbon monoxide determination in expired air as a practical method of diagnosis of acute CO intoxication. Med. lavoro (Milan) 49:428-441 (June-July) 1958.

Several methods of carbon monoxide determination in expired air were submitted to a series of tests. It was found that the best containers for collecting and keeping expired air samples were rubber footballs with plastic covers. The simplest and most reliable sampling technique consisted in collecting the last fractions of expired air, without effort, through a filter. Iodine pentoxide indicator ampoules gave a false positive CO reaction in a range of 0.5% in the presence of ethanol vapors, 0.2% with acetone vapors, and 0.1% with benzol vapors. Metabolic products from ethanol excreted through the lungs within 2 hours from time of ingestion can interfere more markedly with the colorimetric reaction, giving values corresponding to 6-8% HbCO in conditions of clinically evident alcoholic inebriation. The correlation of CO values in the expired air to CO extracted by Roughton-Scholander's method shows a coefficient $r = 0.616$, while the correlation to HbCO values according to Heilmeyer's method shows a coefficient $r = 0.578$ (in both cases $P < 0.001$). This is a satisfactory correlation, since the correlation of extracted CO to HbCO is lower. Simplicity, rapidity, and low cost are the advantages of the present method that make it especially applicable for clinical use. - APCA 2803

193. Peffek, R.: Mass poisoning with carbon monoxide. Pracov. Lek. 17:24-25, 1965.

The author describes in this paper an extraordinary leakage of carbon monoxide from a defective gas-conduit, that seeped under the road pavement to a distance of 28 meters where it accumulated in a watermain shaft. 6 days later work was started in the watermain shaft and two workers suffered a lethal intoxication. It is interesting that even the prescribed 10 minutes ventilation of the shaft could not avert the occurrence of this accident. - Author's Abst.

194. Raskin, N., and Mullaney, O.C.: The mental and neurological sequelae of carbon monoxide asphyxia in a case observed for fifteen years. J. Nerv. & Mental Dis. 92:640-659 (Nov.) 1940.

Author describes the mental and neurological sequelae of a patient who survived, for 15 years, a case of CO asphyxia. This patient developed Parkinsonian's syndrome, and the mental picture was one of involution melancholia. The extensive literature of case studies of patients who survived CO poisoning for a few days or months is also reviewed. - AGC

195. Rothschild, J.E.: Carbon monoxide poisoning. Amer. Pract. 13: 213-218 (March) 1962.

In reviewing literature, author discusses the overall effect of CO on the health of man. He also reports a case of acute CO poisoning in which he used exchange transfusion to treat the victim. - AGC

196. Sayers, R.R., and O'Brien, H.R.: The treatment of carbon monoxide poisoning. Pub. Health Rep. 37:271-274 (Feb. 10) 1922.

Carbon monoxide poisoning is one of the most widely distributed and most frequent of industrial accidents. The gas is a product of incomplete combustion and is without color, odor, or taste; therefore, its presence is frequently unsuspected in many places where it exists. It is an ever-present danger about blast and coke furnaces and foundries. It may be found in a building having a leaky furnace or chimney or a gas stove without flue connection, such as a tenement, tailor shop, or boarding house. Hospitals receive a great number of victims of poisoning, whether by accident or in an attempt at suicide, from artificial illuminating gas. Persons may be affected by leaks wherever water gas is formed or used. The exhaust gases of gasoline automobiles contain from 4 to 12 per cent of carbon monoxide, and in closed garages men are not infrequently found dead beside a running motor. A similar danger may arise from gasoline engines in launches. The gas is formed also in stoke-rooms, in gun turrets on battleships, in petroleum refineries, and in the Leblanc soda process in cement and brick plants. In underground work carbon monoxide may appear as the result of shot firing, mine explosions, or mine fires, or in tunnels from automobile exhausts or from coal or oil burning locomotives.

Carbon monoxide exerts its extremely dangerous action on the body by displacing oxygen from its combination with hemoglobin. The affinity of CO for hemoglobin is about 300 times that of oxygen. Because of this, even when only a small amount of the poisonous gas is present in the air breathed into the lungs much of the hemoglobin is locked up in combination with CO and so cannot keep up its usual work of carrying oxygen to the tissues. Author describes symptoms of acute and chronic CO poisoning, and suggests treatment. - From Text-AGC

197. Shafer, N., Smilay, M.G., and MacMillan, F.P.: Primary myocardial disease in man resulting from acute carbon monoxide poisoning. Amer. J. Med. 38:316-320 (Feb.) 1965.

The purpose of this paper is to present a case of myocardial damage resulting from acute carbon monoxide poisoning. A review of the literature reveals a paucity of such reports. The standard textbooks of medicine make little or no mention of cardiac signs and symptoms arising from carbon monoxide poisoning, but emphasize instead cerebral involvement. The case presented herein is of further interest as the patient has remained symptomatic to the present time and has shown persistent changes on the electrocardiogram; the electrocardiographic patterns reported thus far consist of transient and reversible changes. - Authors' Abst.

198. Shillito, F.H., Drinker, C.K., and Shaughnessy, T.J.: The problem of nervous and mental sequelae in carbon monoxide poisoning. J. A.M.A. 106:669-674 (Feb. 29) 1936.

The New York metropolitan area was chosen for a study of nervous and mental sequelae of carbon monoxide poisoning. It is known that at least 21,143 acute exposures of all degree occurred there in a ten year period. For the same period a survey of the state mental institutions serving the meteropolitan area of New York City showed thirty-nine certain cases of sequelae of carbon monoxide. Such patients formed 0.05 per cent of the total admissions. Serious mental or nervous sequelae of carbon monoxide poisoning are thus infrequent in relation either to other nervous and mental diseases or to the number of acute exposures.

Study of case records reveal that when nervous or mental damage occurred the acute carbon monoxide intoxication was extreme. Complete unconsciousness was invariable and the most active resuscitative measures were necessary. None of these cases followed so-called chronic carbon monoxide exposure over a long period of time.

A clear period of from seven to twenty days preceded the onset of symptoms in one third of the cases. In the remainder of the cases the symptoms started immediately following the poisoning.

Mental sequelae consisted of a confusion psychosis, with disorientation, lack of judgment and amnesia. Motor overactivity and aphasia were much less common. Hallucinations, delusions or convulsions played no conspicuous part.

Nervous sequelae consisted of signs varying from slightly increased deep reflexes to well advanced parkinsonism. Sensory disturbances, such as skin anesthesia and peripheral motor neuritides, were also encountered. These cases all showed improvement, but the final result depended on the degree of initial damage.

In the total group of forty-three cases, twenty-three patients recovered completely, nine suffered permanent nervous or mental sequelae and eleven died. - Authors' Sum.

199. Smith, G., and Sharp, G.R.: Treatment of carbon monoxide poisoning with oxygen under pressure. Lancet No. 7156:905-906 (Oct. 22) 1960.

Two cases are presented in which the patients arrived at a hospital separately but within a short period of time, in an unconscious and deeply unconscious state following exposure to carbon monoxide in a closed room. Before treatment the carboxyhemoglobin levels were established as 26 and 50% respectively. The patients were placed in a pressure chamber, where the pressure was raised to 15 lb./in.^{2} over a period of 15 minutes, and each patient was given oxygen. The 1st patient revived very rapidly; the 2nd patient was able to breathe without the aid of the resuscitator after 20 minutes and after 40 minutes could answer questions and move his limbs purposefully. At the end of an hour the pressure was reduced over a period of 31 minutes, to atmospheric pressure. Samples of venous blood taken at this time, at atmospheric pressure, showed no carboxyhemoglobin to be present in either case. - APCA 3736

200. Spencer, T. D.: Effects of carbon monoxide on man and canaries. Ann. Occupat. Hyg. (London) 5:231-240 (Oct.-Dec.) 1962.

Since the scientific literature contained little information on the measuring of the effect of CO on canaries, and none since the refinement of measuring techniques which have occurred in the last decade or so, the author a few years ago carried out a series of tests of such effects. There are 3 major differences between the effects of CO on man and of those on the canary. The 1st is the difference in what can be measured. In man the gas produces headache, dizziness, and nausea but these symptoms cannot be assessed with any certainty in the canary. The time that the canary falls off the perch is the only measurement that can be made with any assurance. It is obvious that there is no equivalent to the walking or working man; all canaries are "resting." The 2nd is that a canary reaches a state of equilibrium with the CO it is breathing much more quickly than a man does. If the atmosphere contains enough CO to cause all canaries put in it to fall of their perches (i.e., more than 17.5 parts/10,000 parts of air), this fall will occur within 20 minutes and usually within 10. A resting man could be 4-5 hours in such a concentration before losing consciousness. At concentrations of more than 17.5 parts the canary would fall off its perch nearly always before a walking man had developed any symptoms of poisoning and always before a resting man had done so. It is this fact, of course, which has made the canary so valuable in rescue operations. The 3rd difference is 1 which does not appear to be widely known. It takes 2 or 3 times the concentration of CO to produce in a canary effects which can be considered as equivalent to those in man. The lowest concentration of CO which appeared to produce any effect whatever in a canary seemed, from these observations, to be 6 parts/10,000 parts. The lowest concentration that will make any canary fall off its perch is 12.5 parts; in man unconsciousness will occur in 4 or 5 parts. It has always been considered that the canary was more "sensitive" to CO than man. In man, hemoglobin has about 250 times the affinity for CO than it has for oxygen; in the canary this figure appears to be 110. In 1 sense of the word a canary is, therefore, not nearly as "sensitive" to CO as man. This fact is more than counterbalanced in CO of more than 20 parts by the speed at which the canary's blood comes into equilibrium with the atmosphere breathed. At the lower levels, and particularly in 12 parts/10,000 parts of CO or less, a canary will not only be useless but will be a dangerous cause of false confidence. - APCA 5389.

201. Tronzano, L., and Coscia, G.C.: Radial paralysis in a case of acute carbon monoxide intoxication. Rass. Med. Indust. 33:401-403 (May-Aug.) 1964.

A case is reported of paralysis of the right arm in a 38-year-old worker acutely poisoned by carbon monoxide. The paralysis persisted for three months, although no signs of central-nervous-system distress were evident. This case demonstrates the occurrence of isolated lesions in the peripheral nerve trunks of the arm during acute carbon monoxide poisoning. - NASA 30287

202. Turner, J.W.A.: Parkinsonism: Aetiology and Treatment. London Clin. Med. J. 5:41-49 (Jan.) 1964.

The following paragraph is taken from this paper in the section entitled: "Aetiology of the Parkinsonism Syndrome".

"The occurrence of Parkinsonism following acute poisoning is well authenticated, and pathological softening of the anterior part of the globus pallidus has been found in patients who have survived for 24 hours or more after carbon monoxide poisoning. In some recorded cases there has been an interval of months, even up to a year or more before Parkinsonism developed, but in the most clear-cut case I have personally seen, well-marked Parkinsonism was present two to three weeks after an unsuccessful suicidal attempt in which the patient had been unconscious for about 48 hours. Although the condition may become worse for some months, progressive deterioration over the course of years does not usually take place.

203. Vyskocil, J.: "Neurohumoral regulation" in acute and chronic carbon monoxide poisoning. Arch. Gewerbepathol. Gewerbehyg. 15:457-472, 1957.

The varying views on the mechanism of carbon monoxide poisoning, clinical findings, laboratory and other tests of 40 cases of acute and 29 cases of chronic carbon monoxide poisoning are discussed in this paper. In summary, the author states that in acute poisoning during the first few days there is leucocytosis, diminution in the eosinophil count, increase in blood sugar, glycosuria and pathological values of the adrenaline test (Thorn test) and of the Walsh-Robinson-Kepler water test. These pathological findings disappear in most cases, in about 14 days, but in other instances signs suggestive of damages to the central nervous system develop gradually. Congestion of the adrenals, pancreas, liver and spleen were found in 23 fatal cases. Among the 29 persons who had for an average period of 8 years worked in an atmosphere containing carbon monoxide, the findings were enlargement of the thyroid (38%), loss of hair (45%), diminution in potency (17%), pathological values in the adrenaline test (59%), increase in blood sugar (41%) and pathological values in the water test (27%). - AGC

204. Zaffiri, O.: Hypothermia in treatment of acute carbon monoxide poisoning. Rass. Med. Indust. 33:433-436 (May-Aug.) 1964.

A case is reported of acute carbon monoxide poisoning treated with hypothermia to 32°, and with recovery of the patient without sequelae after 5 days in a coma. The decreased metabolic requirements during hypothermia provide a good oxygen supply to the cerebral, hepatic, cardiac, and renal tissue, thus defending them from the action of hypoxia. Moreover, the hemoglobin dissociation curve is displaced to the left. From a theoretical viewpoint, hypothermia appears to be the most rational treatment to avoid hypoxia of the nervous and cardiovascular systems and the resultant sequelae in those who survive the coma of carbon monoxide poisoning. - NASA 80290

205. Zorn, H.: Diagnosis and therapy of CO-poisoning in practice. Münchner Med. Wochenschrift 106:235-239 (Feb.) 1964.

The technical and medical problems concerning the protection of health by preventing the perilous effects of the old gas containing much carbon monoxide and the modern city gas with little CO are discussed. The symptoms of CO-intoxication vary and render the diagnosis frequently very difficult; with the appropriate test-tubes, however, it can be stated easily. Primary treatment depends on the hypoxemic condition and ranges from simple mouth-to-mouth breathing to high pressure O_2-respiration. Even the mild CO-intoxication requires treatment. Adequate oxygen therapy prevents or lessens sequelae. Further specific and non-specific conservative therapy of CO-poisoning is discussed. - Author's English Sum.

effect of chronic (long term and low) concentrations

206. Austen, F.K.: The medical grand rounds. Massachusetts General Hospital. Amer. Pract. 13:171-185, 1962.

Among the cases discussed is one concerning a medical problem caused by CO, in connection with the construction of a garage under the Boston Common. The physiological and chemical reactions of oxygen and CO as they become bound to hemoglobin are described. The rules of how CO and hemoglobin combine are summarized in a simple equation. The severity of the symptoms of anoxia from CO poisoning as compared with anemia are explained. - AGC

207. Automobiles and air pollution. J. AMA 162:134 (Sept. 8) 1956.

In a report of the Fuel Research Station to the Royal Society of Health, England, it is pointed out that air pollution caused by automobile exhaust gases is small compared with that caused by coal combustion; however, since vehicular exhaust gases are emitted in the streets at a low level, there is little chance of their being dispersed before being inhaled. In gasoline engines, the carbon monoxide emitted is about 4%, and in diesel engines about 0.1%. Practically no benzopyrene is detected at gasoline engine loads exceeding 50%, while in efficiently run diesel engines only a trace is evident. Yearly pollution from carbon monoxide totals 24 metric tons of which 10 tons are from industrial chimneys, 10 tons from domestic appliances, and 4 tons from automobile exhausts. The average carbon monoxide in the air of London streets in 1955 was 15 ppm. In the smog of Jan. 1956, the carbon monoxide content rose to 50 ppm in London and 80 ppm in Salford, England. Data indicate that the average pedestrian experiences an effect of carbon monoxide poisoning at a concentration of 50 ppm after exposure of 4 to 8 hours. - LC

208. Baetjer, A.M.: Chronic exposures to air pollutants and acute infectious respiratory diseases. Arch. Indust. Hyg. & Occupat. Med. 2:400-406 (Oct.) 1950.

Data in this review, obtained from studies of the health of persons who had been exposed to specific chemical contaminants of the air have not yielded any definite evidence that chronic inhalation of such chemical contaminants in low concentrations affects susceptibility to acute infections of the respiratory tract. Author states that the data available at present are entirely insufficient to enable one to draw any definite conclusions, and suggests further fundamental research along the following four subjects: 1. Basic studies on the physiologic effects of air pollutants on the body tissues; 2. animal experimentation on the effects of these substances on susceptibility to infectious diseases; 3. industrial morbidity studies in relation to known exposures and 4. well controlled epidemiologic studies. Not until such data become available can any positive statement be made concerning the effects of chronic inhalation of atmospheric contaminants on acute infections of the respiratory tract. - Author's Conclusions Modified - AGC

209. Beck, H.G., and Fort, W.: Chronic carbon monoxide poisoning. Ann. Clin. Med. 3:437-443, 1924-1925.

Two case studies of chronic carbon monoxide poisoning are discussed in detail in this paper. Because of the manifold and protean character of the clinical manifestations, only a few of the more common symptoms could be given in this paper. The pallor of many patients resembled a high grade of anemia, as well as a group of symptoms are suggestive of anemia in the presence of a red cell count of over 5,000,000. This condition is of considerable diagnostic significance. There is no specific antidote for chronic carbon monoxide poisoning and treatment has to be symptomatic.

An English bull dog was named the victim in a third case study of carbon monoxide poisoning. The blood examination showed a hemoglobin of 95%, erythrocytes 5,120,000 and leukocytes 12,250. There were no morphological changes in the red cells. - AGC

210. Beck, H.G.: The clinical manifestations of chronic carbon monoxide poisoning. Ann. Clin. Med. 5:1088-1096, 1927.

It has been stated that CO, a product of many industries, ranks 2nd as a death-dealing agent. Certain occupations, e.g., working in garages, around blast furnaces, gas works, smelting works and firing gas engines are particularly hazardous in chronic CO inhalation. Combustion sources in the home and in the streets give off much CO. The nature of CO gas is discussed. The severity and clinical course of the symptoms produced depend upon the concentration of CO gas, frequency and duration of exposure, temperature and humidity, physical exertion, health of the individual, admixture of other poisonous gases and individual susceptibility. In an attempt to meet the increased demand for O_2, because part of the hemoglobin is tied up with CO, the blood often contains an increased amount of red blood cells and hemoglobin. In 665 steel workers, the red counts ranged from 6,000,000-9,676,000 and hemoglobin content from 95-125%. In a large % of fatal cases of CO poisoning, the cause of death may be attributed to cerebral lesions, e.g., congestion of the meninges and brain substance, hemorrhage into and softening of the internal capsule, lenticular nucleus and adjacent structure. Pneumonia often follows as an immediate sequence to acute poisoning. The various stages of symptomatology in acute poisoning are described. In some cases, a delayed CO poisoning occurs. Severe chronic CO poisoning presents many of the same symptoms as the mild acute form. The most frequent are headache, dizziness, muscular weakness, disturbance of gait, parasthesia, breathlessness on exertion and nervous and emotional instability. The muscular symptoms are particularly pronounced. Several illustrative cases where the symptoms simulated ulcers, hyperthyroidism and pernicious anemia are reported. Diagnosis and prognosis are also discussed. - Kett.

211. Beck, H.G.: Slow carbon monoxide asphyxiation. A neglected clinical problem. J. A.M.A. 107:1025-1029 (July-Sept.) 1936.

A series of carefully studied cases of slow carbon monoxide asphyxiation has been studied.

The symptoms exhibited have been correlated with the pathologic lesions produced in experimental animals and found at autopsy.

The results establish the fact that slow carbon monoxide asphyxiation (anoxemia) produces a definite clinicopathologic entity despite views held to the contrary.

The symptoms arise predominantly from organs rich in blood supply, thus demanding much oxygen, such as the central nervous system and the heart muscles.

Owing to doubt and uncertainty as to the actual existence of the malady and a scant literature on the subject, the condition is not generally recognized by the profession and its importance has been underestimated.

Since there is no medicinal remedy when the organic changes have once developed, treatment must be directed toward its prevention by proper public health measures. - Author's Sum.

212. Beck, H.G.: Chronic carbon monoxide anoxemia: Clinical syndromes. Southern Med. J. 30:824-829 (Aug.) 1937.

The object of this paper is not to discuss the immediate effects of acute carbon monoxide poisoning as the incidence and the nature of this condition are well known; but to consider the more remote effects of acute poisoning and the effects of chronic poisoning produced by frequent and prolonged periods of exposure to sublethal amounts, and to describe some of the characteristic syndromes.

213. Beck, H.G., and Suter, G.M.: Role of carbon monoxide in the causation of myocardial disease. J.A.M.A. 110:1982-1986 (June 11) 1938.

In a group of 136 persons who had been intermittently exposed to carbon monoxide over varying periods, myocardial symptoms were frequently manifested.

The lesions affecting the heart, brain and other organs are primarily vascular, consisting of small hemorrhages and perivascular infiltration with focal necrosis. When the heart is affected, coronary thrombosis frequently develops, as ascertained by postmortem and electrocardiographic studies.

Hemorrhagic lesions affecting the heart muscle have been produced experimentally in animals subjected to varying amounts of carbon monoxide in inspired air.

The impression that unless the patient dies in acute asphyxiation no harm may result is erroneous.

Patients who apparently recover from acute asphyxiation frequently have later manifestations, which appear in from three to seven days. These are known as delayed symptoms, or sequelae, and may affect the heart, brain or other organs and terminate fatally.

Those who survive the delayed manifestations may completely recover or ultimately may have severe organic disease of the heart or of other organs, to which they finally succumb.

Lesions may occur simultaneously in the heart and the brain, as evidenced by clinical studies and post mortem observations.

In order to make a positive diagnosis of chronic myocardial disease resulting from carbon monoxide, it is essential that an accurate history be obtained with respect to exposure to gas, exhibition of symptoms of anoxemia, clinical course of the disease and absence of preexisting cardiac lesions. - Authors' Sum.

214. Birren, J.E., Fisher, M.B., Vollmer, E.P., and King, B.G.: Effects of anoxia on performance at several simulated altitudes. J. Exp. Psycholog. 36:35-49 (Feb.) 1964.

This paper reports the results of a series of tests on humans exposed to simulated altitudes in a low pressure chamber. These tests were made not to determine possible bases for personnel selection but to provide limited performance norms for subsequent studies of variables superimposed on anoxia, e.g., carbon monoxide. The purpose of the present investigation is similar to that of many other studies employing sensorimotor tests, that is, to appraise the efficiency of personnel under an environmental stress.

215. Bjerver, K., and Goldberg, L.: Alcohol tolerance in individuals with chronic producer-gas intoxication. Quart. J. Stud. Alcohol 9:329-351, 1948.

One subjective symptom of "chronic producer-gas intoxication," believed to be due to prolonged exposure to carbon monoxide, has been reported to be a lowered tolerance to alcohol.

The alcohol tolerance in 11 patients with chronic producer-gas intoxication was established quantitatively by a number of tests in relation to the alcohol curve in the blood after ingestion.

The results were compared with those in a control group of 7 healthy subjects, examined during the same experiment, and to the findings in a larger control group of 49 subjects, determined previously.

The tolerance to alcohol in the patients (experimental subjects) was the same as in the healthy control subjects. No difference was found between the patients with chronic producer-gas intoxication and the control subjects either in regard to the blood alcohol curve - whether in β, r or maximum - or in regard to alcohol tolerance. The threshold for a battery of tests showed the same values in the patients as in the controls.

216. Breysse, P.A.: Chronic carbon monoxide poisoning. Indust. Med. & Surg. 30:20-22 (Jan.) 1961.

Author summarizes this review of eleven papers with the following: "Some of the attitudes that have been encountered are reflected in this review. At once it becomes apparent in some instances that what has been termed chronic carbon monoxide poisoning is not other than repeated episodes of acute poisoning. This indicates chronic exposure rather than chronic poisoning. Other situations that have been characterized as chronic poisoning relate to the well-known sequelae that sometimes follow severe acute poisoning. Notwithstanding, there is warrant to iterate the statement contained in the 1930 International Labor Office publication: The question of the existence or not of chronic CO poisoning has been much discussed and is not yet settled." - quoted from text-AGC

217. Chronic carbon monoxide poisoning. New Engl. J. Med. 261:1248-1249 (Dec. 10) 1959.

In this review it is noted that carbon monoxide poisoning in the acute form has long been recognized but that the slower and more insidious form of intoxication, with intermittent symptoms and vague relations to the sources of poisoned atmosphere, is only now being brought into prominence. The basic facts were mostly gathered in Europe and about 10 years ago were published in a Danish monograph by Grut (Copenhagen, Ejnar Munksgaard, 1949). Recently the subject has been activated with report from health authorities in the state of Connecticut. Carbon monoxide poisoning in a chronic form, because of psychiatric and neurologic symptomatology, is frequently incorrectly diagnosed as epilepsy. It is possible that some people are more susceptible to this form of attack than are others, but the timing of attacks, their nature, the mental changes, and the intermittent symptoms should lead to a diagnosis in all persons exposed to carbon monoxide whether inside or out-of-doors. - APCA 3949

218. De Bruin, A., Vroege, D., and Van Haeringen, A.: Study of carbon monoxide uptake in traffic policemen. T. Soc. Geneesk. 43:146-151 (March 5) 1965.

The HbCO-content of the blood of 36 municipal traffic policemen--non-smokers--in Rotterdam exposed to exhaust from motor vehicles, during one to four hours, has been measured. The data were compared to those of a control group of 16 non-smoking policemen working in the office. Blood samples have been taken before and after work. The HbCO-content was on the average 0.93% before work and increased to 1.11% in the exposed group, whereas the HbCO-content in the control group remained about the same. The peak CO-content in the air was between 5-15 ppm. The chemical analysis has been performed with two independent methods. - APCA 65-154

219. Duvoir, M., and Gaultier, M.: Etiology: Clinical and chemical study of forty cases of chronic industrial carbon monoxide poisoning. Arch. Mal. Prof. 7:449-452, 1946.

Scepticism concerning the reality of chronic CO poisoning has been justified by the multiplicity of symptoms attributed to the disease. This paper attempts to establish chronic CO poisoning as a reality and as an individual disease by establishing a clinical and chemical basis.

Using Nicloux' method to determine the amount of CO in 40 subjects, a blood level above .4 to .5 cc. per 100 cc. blood is considered abnormally high. Cessation of exposure resulted in a gradual reduction of the blood level. In two months, one subject went from .85 to .52, another from 2.5 to .52, another from .82 to .46, etc. The blood level persisted for a longer time in a number of cases, a typical case being: .88 after exposure, .80 after 3 months, .30 after 5 months. Rest alone results in improvement, but oxygen therapy accelerates recovery. Vitamin B_2 also hastens return of blood levels to normal although its action is neither immediate nor constant.

Chronic CO poisoning is characterized by this elevated blood level and by three major symptoms, always appearing together. These are, 1) Asthenia. The asthenia is almost constant. Muscular fatigue, intellectual apathy, depression, slowness of speech, and impaired memory are frequently found, and sexual impotence is occasionally concurrent. 2) Severe headache. The headache is persistent, and usually more severe during exposure, although it may continue for several hours after work. It is not localized to any specific brain area. 3) Vertigo and syncope. Vertigo is frequent and may signal syncope. Syncope is a less important differentiation, since it is so often found in acute poisonings.

Pathogenesis and mechanisms remain obscure, but determination of blood level of CO, the constancy of symptoms, and improvement occurring during cessation of exposure are indicative of the reality of chronic CO poisoning.

220. Piandaca, S., and Vercellotti, E.: Effects on the sick and accident rates in subjects exposed to the risk of chronic carbon monoxide poisoning. Rass. Med. Indust. 33:360-379 (May-Aug.) 1964.

A statistical survey was made of the sickness and accident rate in a population of workers exposed to the risk of chronic carbon monoxide poisoning. A constant increase was found in the accident rate, and an increase was also found in the sickness rate, which was only statistically significant in relation to the relapses of the number of subjects who were smokers. The increased accident rate was probably due to the momentary action of the high level of carboxyhemoglobinemia. A direct causal relationship may be found in the sickness increases and in the short indispositions identified in subjective symptomatology with those due to sudden increased environmental carbon monoxide concentrations, along with cigarette smoke. - NASA 80285

221. Gilbert, G.J., and Glaser, G.H.: Neurologic manifestations of chronic carbon monoxide poisoning. New England J. Med. 261:1217-1220 (Dec. 10) 1959.

A detailed case history is given of a patient suffering from chronic carbon monoxide poisoning. The condition was verified by the finding of a significantly-elevated blood carbon monoxide level. A detailed occupational history was obtained indicating that the patient had been a policeman for 18 years. His first few "spells" had occurred four years before hospital admission in 1958 at the age of 50 while he was assigned to directing heavy automobile traffic. Fearing that his job was too strenuous, he had requested transfer to the police garage and had served as a mechanic there for the past three years. It was often necessary to run the motors of the police cars in the garage, particularly in the repair of police radios which required a running motor for their operation. The garage doors were usually left open but were closed often after March to keep out the sun. The time of closing of the garage doors corresponded to the period of exacerbation of the patient's symptomatology. The patient had anorexia, weight loss, a fluctuating organic mental syndrome, and recurrent episodes of loss of consciousness, each attack preceded by a period of dizziness and ataxia. After the patient had discontinued his work, serial electroencephalograms showed progressive clearing of focal and paroxysmal abnormalities, correlated with clinical improvement. It is noted in the text--and commented editorially, in the same journal, pp. 1248-1249--that unless the occupational history is carefully taken, the different diagnoses can be difficult. The patient under discussion had received anticonvulsant therapy for 2-1/2 years previous to the correct diagnosis. It is noted in the editorial also that there were a few more attacks which were always associated with driving a farm tractor. It was found that the patient had a habit of walking behind the tractor where the exhaust was on a level of about his head. When this occupation was also discontinued he recovered fully, and the diagnosis was confirmed. - APCA 3185

222. Grudzinska, B.: Electroencephalographic patterns in cases of chronic exposure to carbon monoxide in air. Folia Medica Cracoviensia 3: 493-515, 1963.

The purpose of this study was to ascertain whether chronic exposure to CO produces pathologic changes in man and to analyse electro-clinical correlations. Sixty workers from gas works and coking plants exposed to CO concentrations not exceeding 0.01% were studied. The control group consisted of 30 workers similarly employed but not exposed to CO. Only healthy individuals were included in both groups without history of cranial trauma or acute CO poisoning. Examination included determination of erythrocyte counts, Hb and COHb levels, complete history, functional tests of the vegetative nervous system. EEG's were made at rest and after activities. CO exposure was confirmed by examination of COHb. The mean level of COHb was 7.4% in the exposed group, and 3% in the control group. The COHb level exceeded 10% in 11 persons of the exposed group. A neurasthenia syndrome was diagnosed in 63% of the exposed group and in 40% of the control group. The type and intensity of complaints in each group was studied. Statistical analysis of the differences revealed significantly greater incidence of headache and general debility in the exposed group.

Among the normal tracings from the exposed group there was a significantly higher proportion of flat, low-voltage tracings with scanty alpha rhythm ($p < 0.01$).

Statistically significant electroclinical correlations were found in the group exposed to CO. All the pathologic tracings and 81% of the low-voltage tracings and those with scanty alpha rhythm were found in individuals with neurasthenic syndromes. In addition, all the tracings of the first sleep phases were also found in neurasthenic individuals.

From the findings it may be concluded that chronic exposure to low concentrations of carbon monoxide does not cause distinct changes in the nervous system, but may have a certain inhibitory effect on the bioelectric activity of the brain, manifested clinically as neurasthenia and in the EEG as scantly low-voltage alpha rhythm and tracings of the first sleep phases. However, since these changes are nonspecific, EEG examination in cases suspected of chronic CO poisoning is not decisive, although it may be auxiliary factor in making the diagnosis. - Author's Sum. Modified

223. Grut, A.: Chronic Carbon Monoxide Poisoning, a Study in Occupational Medicine. Ejnar Munksgaard, Copenhagen, 1949, 229 pp.

The following topics are discussed in twelve chapters: 1. Introduction, 2. Exposure to Carbon Monoxide, 3. Acute Carbon Monoxide Poisoning, 4. Chronic Carbon Monoxide Poisoning, 5. Hyperthyroidism Following Exposure to Carbon Monoxide, 6. Diagnosis of Chronic Carbon Monoxide Poisoning, 7. Aggregate Result of Examinations of Producer Gas Drivers and Other Workers Exposed to Carbon Monoxide, 8. The Individual Working Processes Connected with Producer Gas Driving, 9. Development and Course of Chronic Carbon Monoxide Poisoning, 10. Variations in Susceptibility to Carbon Monoxide, 11. Pathogenesis and Pathological Anatomy, and 12. Treatment and Prophylaxis.

Various methods to determine the CO content of the air and of COHb are described. Exposures are ascertained by the detection of a pathological COHb% of CO in the air of places of work or by examination of the working process.

The occurrence and severity of chronic CO poisoning of drivers and mechanics of motor vehicles, respectively of fuel trucks, of traffic policemen and workers in tunnels are discussed.

Acclimatization to CO has been experimentally verified in animals but experiments with man are not convincing. Pathologic neurological symptoms and histological changes have been found in the brains of dogs exposed to 0.01% CO, but only slight histological changes have been described in human beings after chronic CO poisoning. The bibliography contains 180 references. - AGC

224. Hackney, J.D., Lashier, H., Lynn, K., and Spier, C.: Comparative effect of two sources of exposure to carbon monoxide on carbon monoxide hemoglobin levels. Presented at the Air Pollution Research Conference on "Effects of Motor Vehicle Emissions on Health," Dec. 6, 1961, Los Angeles, Calif.

The comparative effect of two sources of carbon monoxide exposure, e.g., ambient CO and ambient CO plus cigarette smoke on the COHb of two normal subjects working as a team is discussed in this study. The rebreathing method for indirect estimation of COHb as previously described (1) was used in this study for the frequent monitoring of COHb. Samples of the ambient air were collected almost continuously during the experimental run as a means of representing the integrated total ambient CO exposure. - Authors' Introduction

225. Halperin, M.H., Niven, J.I., McFarland, R.A., and Roughton, F.J.W.: Variations in visual thresholds during carbon monoxide and hypoxic anoxia. Fed. Proc. (Abstract) 6:120-121, 1947.

The comparative and combined effects of carbon monoxide and hypoxic anoxia on human visual intensity discrimination, as well as the effects of normal and high O_2 atmospheres during recovery from CO, were investigated.

In previous studies we have found that the measurement of visual intensity discrimination thresholds at a low level of illumination provides a very sensitive, useful and precise quantitative index of the physiological disturbance caused by oxygen deprivation. We therefore applied the same technique in measuring the effects of small amounts of CO. Extensive studies were carried out on four well-trained subjects.

A given increase in % COHb in the blood at sea level produces an effect approximately equal to that of an equal decrease in % O_2Hb due to hypoxic anoxia. At simulated high altitudes, a given % COHb produces an impairment equivalent to a further ascent which would cause an equal additional decrease in % O_2Hb. The visual threshold is therefore much more sensitive to CO than are other physiological functions so far investigated.

In studying the recovery from CO, we found that the inhalation of oxygen, in addition to its value in accelerating the elimination of CO, had another beneficial effect as compared with the inhalation of ordinary air. An added improvement equivalent to a decrease of about 5 to 7% COHb was produced by breathing oxygen. When the subjects then breathed ordinary air, the thresholds were again impaired by this amount. If, instead of oxygen, the subject breathed ordinary air throughout the recovery period, the visual thresholds failed to recover as rapidly as the % COHb declined. - Authors' Abst.

226. Hayhurst, E.R.: Carbon monoxide and automobile exhaust gases. Amer. J. Pub. Health 16:218-223 (March) 1926.

This paper deals with the problem of diagnosis of carbon monoxide poisoning, but not with cases where esposure is evident and severe symptoms or death ensue. Author is interested in exposure to limited amounts and whether such symptoms as the common ones of headache, weariness, weakness, dizziness, nausea, vomiting, loss of strength and muscular control, increased pulse and respiratory rates, loss of reflexes, and even coma with intermittent convulsions, cessation of respiration, and death are due to carbon monoxide poisoning or any of the many other possible factors connected with the environment or the condition of the victim. - Author's Abst. Modified.

227. Hofreuter, D.H., Catcott, E.J., and Xintaras, C.: Carboxyhemoglobin in men exposed to carbon monoxide. Arch. Environ. Health 4:81-85 (Jan.) 1962.

This study was designed to appraise the influence of exposure to various sources of carbon monoxide on carboxyhemoglobin levels. Also, the relationship of COHb levels with symptoms associated with CO intoxication was considered. Environmental factors such as smoking, occupational exposure, and commuting to work in a private automobile were not reflected in marked or sustained differences of COHb levels that could be related to these influences. No relation was found between symptoms and COHb values. To summarize the effects of a rather continuous exposure throughout the day, 54 of the subjects were exposed daily to CO in their working environment, while smoking, and while commuting to work in a private automobile. The mean COHb value of this group was 3.8%. This mean was not markedly different from the mean levels observed in groups which had lesser exposure. - APCA 4298

228. Katz, M.: Carbon monoxide asphyxia, a common clinical entity. Canadian Med. Ass. J. 78:182-185 (Feb. 1) 1958.

Forty-one cases of chronic CO poisoning are reviewed. Presenting symptoms are headache, anorexia, dyspepsia, weakness and dizziness, singly or in combination. The finding of a carboxyhemoglobin level of 10% or more plus the relief of symptoms when the patient is removed from exposure confirms the diagnosis. All provincial laboratories are equipped to do carboxyhemoglobin tests. The outdoor worker and the housewife are not immune. Compensation boards will now accept claims for illness arising out of exposure to carbon monoxide on the job. - Author's Sum.

229. Killick, E.M.: The nature of the acclimatization occurring during repeated exposure of the human subject to atmospheres containing low concentrations of carbon monoxide. J. Physiol. (London) 107: 27-44, 1948.

A single human subject was repeatedly exposed to low concentrations of CO in an airtight chamber; each exposure was prolonged until the COHb% attained a steady value.

The degree of acclimatization was indicated by (a) the diminution in severity of the symptoms during successive exposures to the same concentration of CO, (b) the discrepancy between the observed COHb% at the end of an exposure, and the COHb% obtained in vitro when the subject's blood was equilibrated with a mixture containing O_2 and CO at the same partial pressure as in the alveolar air.

Acclimatization was not accompanied by changes in the red-cell count, in the proportion of reticulocytes, or in the blood volume.

The results of inhaling a measured volume of CO from a closed-breathing circuit confirmed the existence of acclimatization, and demonstrated that no appreciable destruction of CO occurred in the body.

The value of the constant for the partition of Hb between O_2 and CO, as determined in vitro, remained unaltered as acclimatization developed.

A possible explanation of these results is discussed. - Author's Sum.

230. Lindgren, S.A.: A study of the effect of protracted occupational exposure to carbon monoxide with special reference to the occurrence of so-called chronic carbon monoxide poisoning. Acta Med. Scandinav. 167 (suppl. 356):1-135, 1961.

The author examined workers occupationally exposed to carbon monoxide and controls paired off principally according to age, from the same types of industry as the exposed subjects. The degree of exposure was judged to be equal to or greater than that of the groups of patients diagnosed to be suffering from chronic carbon monoxide poisoning reported in modern literature. An excessive frequency of headache was found in the group exposed to carbon monoxide. The author interpreted this as a sign of repeated slight acute poisonings and considers he has support for this view in his studies of exposure. Among miners there was also a certain amount of complaints of headaches which was judged to be caused by handling of nitroglycerine. The author found, in a study of the simultaneous occurrence of fatigue, headache and dizziness, a very low frequency of this constellation of symptoms in the exposed as well as the unexposed groups. No difference was found between the groups however. No higher frequency of other clinical manifestations regarded as typical of so-called chronic carbon monoxide poisoning was found in the exposed group than in the control group. Nor did a scrutiny of National health Insurance records for a period of 10 years reveal any differences in the frequency of illness between the two groups. - Author's Abst.

231. Lumic, J.S.: Hearing Deficiencies Caused by Carbon Monoxide (Generator Gas). Acta Oto-Laryngologica Suppl. LXXI, Helsinki, May 1948, 112 pp.

This paper deals with the investigation of possible hearing disturbances due to exposure to carbon monoxide.

Chapter one gives a short review of the origin and development of the CO poisoning problem in Northern European Countries. Chapter two is a review of previous investigations and in chapter three author discusses his own investigations, on the basis of which author states that chronic CO poisoning seems comparatively often responsible for the impairment of hearing.

Seven hundred patients suffering from chronic CO poisoning were examined. Hearing disturbances were ascertained in 73.3% of the patients. A considerable smaller number of hearing disturbances, namely 26.7%, were found in patients who had been exposed to CO in their places of work, but in whom chronic CO poisoning could not be verified. - AGC

232. Lumio, J.S.: Symptoms in the inner ear associated with chronic carbon monoxide poisoning. Arch. f. Gewerbepath. u. Gewerbehyg. 13:139-144, 1954.

Giddiness in 85% of the cases of chronic generator gas poisoning in Finland is often associated with otological disorders, vestibular or cochlear. Actual slight defect in hearing occurred only in 48% of these cases. There was a coincidence in 90% of positive oto-neurological cases with a reduction in the visual field as reported by Helminen.

233. Lutmer, R.F., Busch, K.A., and DeLong, P.L.: Effect of nitric oxide, nitrogen dioxide, or ozone on blood carboxyhemoglobin concentrations during low-level carbon monoxide exposures. Internat. J. Air & Water Poll., in press.

Compared to exposure to CO alone, no enhancement of blood carboxyhemoglobin concentrations was observed following 7-hour exposures of rats and mice to low levels of CO plus NO, NO_2, or O_3. - Authors' Abst.

234. McFarland, R.A., Dunlap, J.W., Hall, W.A., Moseley, A.L.: Human Factors in the Design of Highway Transport Equipment. A Summary Report of Vehicle Evaluation. Harvard School of Public Health, June 1953, pp. 44, figures and tables.

There is one small section on CO in this treatise (pp. 37-39), concerning the adequacy of the cab in regard to overall safety. Tests were conducted on closed, moving cabs and on closed cabs (i.e. all doors, windows, and vents closed) after 15 minutes of standing with the engine idling. A table shows following results:

In %	In PPM 10,000	The Effect Is:
0.01%	1/100,000	No symptoms for 2 hours
0.04%	4/10,000	No symptoms for 1 hour
0.06-0.07%	6-7/10,000	Headache & unpleasant symptoms in 1 hour
0.10-0.12%	10-12/10,000	Dangerous after 1 hour
0.35%	35/10,000	Fatal in less than 1 hour

Authors state that prolonged periods of exposure to 0.01% should not be permitted, and warns that the inspiration of carbon monoxide does not have to produce serious toxic effects to become a source of hazard. Sensory losses, especially in vision occur at low carboxyhemoglobin levels, so that every reasonable control is essential. - AGC

235. Medaglini, E. : Studies on the urinary elimination of 17-ketosteroids and 17-hydroxycorticosteroids in persons affected with chronic intoxication from carbon monoxide. Rass. Neuropsichiat. (Salerno) 16:55-58, 1962.

The author studied the elimination of the 17-ketosteroids and of the 17-hydroxycorticosteroids in the urine of each of a group of persons following chronic exposure to carbon monoxide. The studies revealed a diminished elimination of the substances during the period of intoxication with a gradual return to normal of the adrenal functioning in direct relationship to the improvement of the total clinical picture. - APCA 5103

236. Noro, L.: Carbon monoxide poisoning. Nord. med. 26:771-6, 1945.

The author describes the clinical picture and pathogenesis of CO poisoning and the existence of the poisoning in drivers of motor cars operated by charcoal gas in Finland. Of the 5,000 drivers, who were questioned, symptoms of CO poisoning were found in 67.5% of the cases. The symptoms of acute poisoning were complained of by 3,069; symptoms of chronic poisoning, by 2,506 drivers. In 530 cases the poisoning had caused inability to work. In Finland at present, CO poisoning is the most common occupational disease. - Kett.

237. Pfrender, R.E.: Chronic carbon monoxide poisoning. A critical resume. Indust. Med. & Surg. 31:99-103 (March) 1962.

Author discusses CO combinations with other substances, pathological effects attributable to CO per se, and the nature and extent of acceleration to the gas. Pertaining literature is also reviewed. - From author's sum. -AGC.

238. Ricci, C., Capellaro, F., and Gaido, P.C.: Electrophoretic and immuno-electrophoretic examinations in workers exposed to chronic CO intoxication. Rass. Med. Indust. 33:414-416 (May-Aug.) 1964.

The authors have examined the behaviour of the transferrin with immunochemical methods in individuals exposed to occupational risks from CO. In all the subjects an increase was noted in the globulin fraction of the serum regardless of the time of exposure an increase particularly linked to the globulin fraction (transferrin or siderophillin). - Authors' Sum.

239. Rokaw, S.N., and Massey, F.: Air pollution and chronic respiratory disease. Amer. Rev. Resp. Dis. 86:703-704 (Nov.) 1962.

An investigation was made of the day-to-day variation in respiratory function in a group of 25 selected patients with chronic obstructive airway disease while domiciled at the Ranchos Los Amigos Hospital, a chronic disease center for the County of Los Angeles, compared with a group of normal subjects. The changes in respiratory function were compared with various indices of air pollution, most notably particulate matter, ozone, total oxidants, carbon monoxide, and oxides of nitrogen. There was a marked variability in the performance of the pulmonary function tests described. It was greater for the patient group than for the normal subjects and perhaps was greater than for patients described in other series studied, such as the Canadian Veterans' study. In searching for associations of environmental variation with performance variation, only occasionally was a correlation number found high enough to be "interesting." In only a few instances was there a correlation number that seemed to indicate some major association. In 4 of the patients the carbon monoxide exposed seemed perhaps to be involved, but it cannot be stated that this pattern applied to all patients. Examining time series plots of the results of the various tests, the patients' performances on a given test over a year and a half did not indicate either a cyclic uniform performance for the group or any response to major smog episodes. Other analyses did not indicate a strong relationship of pulmonary performance to the way the patient himself evaluated his feelings about his respiratory disease at the time of the test. - APCA 6333

240. Salen, E.B.: The period of carbon monoxide (the "generator gas epoch") in Sweden 1939-1945. Nordisk Med. 30:923-934 (April 26) 1946.

In connection with the almost total lack of mineral oils in Sweden in 1939 the country was forced to make a sudden change-over to carbon monoxide. In 1941 the number of "gengas" cars in the country amounted to 72000, in 1942 to more than 100,000. The number of persons that during work came in contact with gengas was estimated in 1942 to have amounted to between 200,000 and 250,000. As a result there were a great number of cases of acute carbon monoxide intoxication. Further, there were a number of cases of a disease designated as chronic carbon monoxide intoxication. The diagnosis in question has been based on the following criteria: 1) absence of ascertainable acute CO intoxication; 2) existing sensibility to CO; 3) characteristic picture of symptoms, and the appearance of the separate symptoms in a certain characteristic order of time; 4) the possibility to ascertain, in certain (as a rule serious) cases, a) "supersensibility" to CO on testing, b) positive oto-neurologic test, c) the existence of ophthalmoneurologic changes, d) pathological issue of alcohol test, e) deterioration of memory, concentration, and learning functions, ascertainable through psychiatric examination. The author is of the opinion that this proves the relatively frequent occurrence of lesional and functional brain changes in chronic carbon monoxide intoxication. - Author's Sum. Modified

241. Sayers, R.R., Meriwether, F.V., and Yant, W.P.: Physiological effects of exposure to low concentrations of carbon monoxide. Pub. Health Rep. 37:1126-1142 (May 12) 1922.

The combination of CO with hemoglobin takes place slowly when the subject is exposed to low concentrations and remains at rest, many hours being required before equilibrium is reached.

The rate of combination of CO with hemoglobin takes place much more rapidly during the first hour of exposure than during any succeeding hour, with the subject remaining at rest.

Strenuous exercise causes much more rapid combination of CO with hemoglobin than when the subject remains at rest. The symptoms of CO poisoning are emphasized by exercise.

High temperature and humidity, with a given concentration of CO, cause more rapid combination of CO with hemoglobin than do normal conditions of temperature and humidity.

All symptoms and effects described in this paper are called acute in character. None of the subjects has shown any permanent deleterious effects from the exposure to CO. - Authors' Conclusion

242. Sayers, R.R., and Yant, W.P.: Dangers of and Treatment for Carbon Monoxide Poisoning. U.S. BMRI No. 2476, May 1923, 11 pp.

Properties, chemical and physiological action of CO are discussed. Approximate percentage of CO found in gases from various sources of poisoning are given. Methods of detection by odor, blood methods, detection by tests on small animals, and the Hoolamite detection are described. Time required for various concentrations of CO to procure 80% of equilibrium value of blood saturation are listed, and symptoms caused by various percentages of CO in the blood are described in relationship to percentage of blood saturation. - AGC

243. Savičevic, M., Milijic, B., and Stankovic, M.: Contribution to the study of chronic intoxication with carbon monoxide. Acta Med. Iugosl. (Belgrade) 13:129-137, 1959.

After a review of the literature and an evaluation of the situation following clinical and laboratory examinations of 153 persons over a period of 3 years, the authors give their views of the conditions of chronic carbon monoxide intoxication. There are no specific and constant pathognomic signs of this intoxication. Rather the condition is based on subjective and objective aspects, with the characteristic neuroses, and can be diagnosed as such only after a thorough clinical and laboratory examination. Considered to be the basis for a judgment of the presence of chronic carbon monoxide intoxication are: a concentration of greater than 0.75% in the blood coincident with the finding of more than 50 ppm. of carbon monoxide in the atmosphere, the presence of the cephalic triad, asthenia and vertigo, not yet fully developed encephalitic signs, and the presence of the syndrome of neurovegetative dystonia. Such findings indicate the need to make some drastic changes in the patient's way of life or his work schedule to remove him to an atmosphere of little or no air pollution. It was ascertained as a result of these physical examinations that the person who had been sporadically exposed to high levels of carbon monoxide was subject to various types of neuroses and other personal chronic ailments and was also much more sensitive to further exposure than was the normal, healthy individual. The studies also indicated other variations from the normal in the various electrocardiographic, encephalographic, and metabolic studies. - APCA 3322

244. Shumway, E.A.: Chronic carbon monoxide poisoning an increasing danger to municipalities from automobile traffic. Med. J. & Record 121:657-659 (June) 1925.

This paper reviews and discusses the literature on CO and as author states serves to impress upon the general practitioner the importance of going into the living conditions of his patients, and making inquiries as to the possibility of chronic poisoning by carbon monoxide in those suffering from headache, gastrointestinal disturbances, anemia, lowered nutrition and neurasthenia. - Author's Sum.

245. Skvortzova, N.N.: Pollution of atmospheric air with carbon monoxide in the vicinity of ferro-metallurgical plants. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey, U.S. Dept. of Commerce, OTS 60-21188, Washington, D.C., Vol. 2, 1960, pp. 204-212.

Author describes a study made of the atmospheric air surrounding ferro-metallurgical plants. Concentration of CO ranged between 5.6 - 190 mg/m^3, and in 78.8 - 93.5% of the samples CO concentrations exceeded the allowable limit for maximal single concentrations for the atmospheric air. Results of simultaneous studies of the atmospheric air and the air in dwellings showed a similarity between the CO concentrations. Children, observed during this study, showed a high content of carboxyhemoglobin, and a large percentage of the children developed erythrocytosis, accompanied by subjective complaints , characteristic of CO poisoning.

Author points to the urgent need for abatement of air pollution in particular of CO, because of its deterimental health effects, especially of its effect on young children. -AGC.

246. Stevens, A.M.: Carbon monoxide poisoning. Gradual, cumulative effects in young children, with report of a fatal case, J. A.M.A. 86:1201-1204 (april 17) 1926.

There is a seasonal increase, in the winter, of the hazard of gas poisoning, acute and chronic.

There is a cumulative poisonous effect of repeated or continuous exposure to small amounts of carbon monoxide.

Young children and infants are peculiarly susceptible to gradual carbon monoxide poisoning.

In serious cases of gradual gas poisoning, there will probably be more than 10 per cent of carbon monoxide in the blood.

There is a simple and rapid qualitative test for carbon monoxide in the blood, which will show the presence of 10 per cent or more.

Clinicians should be on the alert to recognize cases of gradual poisoning by carbon monoxide, especially in infants. - Author's Sum.

246a. Vollmer, E.P., King, B.G., Fisher, M.B., and Birren, J.E.: The Effects of Carbon Monoxide on Three Types of Performance, at Simulated Altitudes of 10,000 and 15,500 Feet. NMRI Res. Report X-417, Report No. 7, Feb. 27, 1945, and J. Exp. Phychol. 36:244-251, 1946.

Measurements of the critical flicker frequency threshold, body sway, and the red visual field were made on subjects before, during and after low pressure chamber runs. Twenty subjects with 12 to 22 per cent blood carboxyhemoglobin (COHb) took part in runs at 15,500 feet, and six subjects with 5 to 10 per cent COHb were tested at 10,000 feet. Control runs were made at the same altitudes with the same subjects.

There was a significant impairment of performance at altitude, both under conditions of anoxia alone and anoxia after exposure to carbon monoxide (CO) as compared with performance at sea level.

There was no statistically significant difference between the mean scores of the tests during anoxia alone and during anoxia following administration of CO. Furthermore, the time-performance curves for group means during the hour at altitude are nearly coincident under the two conditions.

All the mean values for performance of each of the three tests at altitude are within one standard deviation of the sea level mean. (More than one-half of the scores for individual performance in the two series may therefore be expected to fall within the range of performance of normal subjects at sea level.)

Individual responses were variable and without correlation with the percentage of increment or of total COHb in the blood.

Three of the subjects who started the experiments showed symptoms of impending collapse at 15,500 feet without CO. One of these had successfully completed his corresponding CO run; the other two did not participate in CO runs.

Five subjects showed symptoms of impending collapse at altitude (one at 10,000, four at 15,500 feet) after they had breathed mixtures containing CO. - Authors' Sum.

247. Strzelczyk, P., and Zenk, H.: Permanent sub-toxic effects of carbon monoxide on organs connecting hearing and balance in gas workers. Archiv Ohren-, Nasen- u. Kehlkopfheilk. 184:81-92, 1964.

Early diagnosis of slow developing chronic CO poisoning is discussed in this paper. Investigations of subjective complaints of workers exposed to CO concentrations of 0.01% and above were made in addition to audiometric and vestibular function tests. Although the effects of acute CO poisoning have been recognized, there are still divided opinions as to damaging health effects following continuous or intermittent exposure to this gas. Experiments with two groups of workers, one group exposed to low CO content and one control group exposed to clean air, were made. Standardized methods of investigation were used, which made it possible to obtain objective results of pathologic changes. Eighty-four percent of the CO group had subjective complaints in comparison with 47% in the control group. The investigations showed a significant difference of subjective audiometric and vestibular symptoms. The noise-audiometry showed that six cases suffered cortical, and four cases retro-ganglion damage. A significant difference in subjective audiometric and vestibular symptoms were noted, caused by sub-toxic doses of CO, in comparison with the control group. - From German-AGC

248. Tope, O.: Health effects from exhaust with consideration of special vehicles and motorized equipment. Städtehygiene. 2/1965.

The noxious components of exhausts from combustion engines are discussed in this paper. Author states that the most dangerous component, the carbon monoxide, causes already in low concentrations symptoms of poisoning. The maximal allowable concentration for carbon monoxide is about 0.01 percent per volume, however repeated concentrations below 0.01% cause pathogenic symptoms. Literature review shows that small amounts of CO may cause chronic poisoning. One investigator established that very low CO concentrations lower the physical and mental capacities of animals. The effect of CO is quite treacherous because symptoms of acute poisoning appear only when a considerable percent of hemoglobin has been changed to carboxyhemoglobin. This leads to disturbance of the orientation and judgment ability in drivers, and driver may fall asleep while driving. Also, the ability to see is impeded, content of the exhaust gas depends very much in the condition of the engine. Author recommends a revision of the construction of combustion engines and the application of electric energy in order to eliminate the potential danger of auto exhaust. -AGC.

249. West, J.B.: Diffusing capacity of the lung for carbon monoxide at high altitude. J. Appl. Physiol. 17:421-426 (May) 1962.

Diffusing capacity of the lung for carbon monoxide (D1) was measured in London (Pb approx. 750 mm Hg), at 15,300 ft (4,700 m; Pb approx. 440 mm Hg), and at 19,000 ft (5,800 m; PB approx. 380 mm Hg) on seven members of the Himalayan Scientific and Mountaineering Expedition, 1960-61. At each altitude D1 was measured at two work levels (300 and 900 kg-m/min) and at three different inspired oxygen tensions in order to separate membrane and blood components of the diffusing barrier. A steady state method was used with mixed expired gas analysis; dead space-to-tidal volume ratio was assumed but calculated D1 was insensitive to this. There was no consistent change in D1 at 15,300 ft (subjects breathing ambient air) compared with sea level, but D1 was significantly increased after 7-10 weeks at 19,000 ft (mean changes of 15 and 19% for work levels of 300 and 900 kg-m/min, respectively). However, this small change in D1 can be wholly accounted for by the increased rate of reaction of carbon monoxide with hemoglobin due to hypoxia and by the increased blood hemoglobin concentration. - Author's Abst.

250. Wilson, E.D., Gates, I., Owen, H.R., and Dawson, W.T.: Street risk of carbon monoxide poisoning. J.A.M.A. 87:319-320 (July 31) 1926.

Policemen at heavily traveled intersections in Philadelphia complained of symptoms of CO poisoning, i.e., headache, slight nausea and muscular weakness. Tests for COHb saturation made on 14 foot-traffic patrolmen after 8 hr. of duty in a crowded section of the city gave values ranging from 0-30%; 6 of them were between 20 and 30%. Another examination of 18 foot-traffic men gave values of from 0.91-2.28% by vol. CO, and values of the COHb saturation ranging from ca. 5-13%. It is concluded that there is a definite street risk of repeated or chronic slight CO anoxemia. Kett.

251. Yarrow, T.J., Jr.: Chronic carbon monoxid poisoning and carbonyl hemoglobinuria: The latter a hitherto undescribed condition. Amer. Med. 4:338-343, 1902.

In April 1900, author called attention to chronic toxemia resulting from inhalation of small quantities of illuminating gas from leaky gas pipe fixtures. He emphasizes the point that chronic CO poisoning occurs more frequently than is thought possible and that it is responsible for many obscure conditions which often remain unsolved. Author advocates the extensive use of the spectroscope in diagnosis of such obscure conditions. Two cases of chronic CO poisoning are described. One is believed to be the first reporting carbonyl hemoglobinuria following or accompanying CO poisoning. - AGC

252. Zorn, I.O., and Kruger, P.D.: The problem of chronic carbon monoxide poisoning. Indust. Med. & Surg. 29:580-581 (Dec.) 1960.

Authors studied industrial carbon monoxide exposure in coke and metallurgical works. Conclusions were reached that no "chronic carbon monoxide poisoning" exists, and recurring carbon monoxide poisoning was identified as "light, recurring carbon monoxide poisoning." There is an important difference between concentration of carbon monoxide and the consumption tolerance. High percentages of carbon monoxide is endured by some persons for short exposures without clinical results. Even slightest doses are sufficient to produce symptoms in others. The boundaries of the consumption-tolerance can be overstepped through prolonged work in an atmosphere containing even slight volumes of carbon monoxide. Because of the way carbon monoxide acts in replacing the oxygen in the hemoglobin, it results in a state of acute poisoning when inbalance is reached. Almost all patients recover in a short time and chronic illness does not occur. - AGC

253. Zorn, H.: On the diagnosis of chronic CO poisoning. (German) Rass. Med. Indust. 33:325-329 (May-Aug.) 1964.

The author has the opportunity of observing a group of workmen who worked in noisy premises and were exposed to low concentrations of CO over a relatively long period on account of a leak of gas which had not been noticed. Examinations and psychological tests when compared to those previously made showed an increase in the excitability and irritability to noises. The percentage of carboxyhemoglobinemia varied between 10 and 20%. The electroencephalogram revealed a picture of extremely unstable frequency. When the leak had finally been found and stopped, the tests returned to normal after eight weeks in the young subjects and after 16 in the elderly and old. These observations led the author to advise a series of examinations and tests to be given to workmen at intervals of 3-4 years, so as to follow up the action of sub-toxic concentrations of CO. - Author's Sum.

experimental exposures

254. Behnke, A.R., White, W.A., Consolazio, W.J., and Pace, N.: A Study of Repeated Daily Short Exposure to High Concentrations of CO. U.S. Naval Med. Res. Inst., Bethesda, Md., Report No. 1, June 7, 1943, pp. 5.

It has been found that the breathing of uncontaminated air by men whose blood contains 20 to 23 per cent COHb results in the complete clearance of CO from their blood well within 24 hours. In fact, the elimination is practically complete within 8 hours after removal from air containing CO.

Four men at rest who breathed 20 parts per 10,000 of CO for 20 minutes daily for four consecutive days, and who reached blood levels of 23 per cent COHb by this exposure, failed to show any cumulative CO saturation of the blood.

Some of these men showed mild symptoms of CO anoxia during the course of the experiment. However, the symptoms did not appear to be progressive or cumulative, and all four men were symptom-free on the last day of exposure to CO.

If pure oxygen is breathed following exposure to CO, previous work indicates that the elimination time is reduced to a period of 30 to 60 minutes when compared with 8 hours for air.

In view of this and other evidence, it is concluded that short (i.e., 20 minutes) daily exposures to concentrations of 15 parts per 10,000 of CO as encountered on the ACV class of naval vessel is permissible for non-flying personnel in view of the emergency nature of the operations leading to such conditions. - Authors' Sum.

254a. **Bogatkov, P.I., Nefedov, Yu.G, and Poletayev, M.I.: Exhaled air as a source of carbon monoxide contamination of the atmosphere in confined chambers.** AID Report 61-82, May 24, 1961, DDC AD 257922.

A study on the contamination of air by exhaled carbon monoxide in confined rooms is reported. Smokers and nonsmokers selected from a number of different professions were confined in groups of three in a testing chamber with a volume of 24 m^3 of air for several days. All possible external sources of CO contamination were carefully checked and eliminated. The air-purification system in the chamber was the peroxide type and could only reduce the concentration of CO. Determination of the CO concentration was made colorimetrically with the

Swedish LKB 3267A device. Results of the test showed that the non-smokers exhaled CO at an average rate of 0.016 mg/l and the smokers, at 0.038 mg/l. After 9-10 days the air of the testing chamber with three persons in it contained 0.023-0.027 mg/l of CO. The authors are of the opinion that the toxic effect of CO consists 1) in the exchange of the oxyhemoglobin in the blood for carboxyhemoglobin and 2) in the suppression of the redox ferments of living tissues. - Authors' Abst.

255. Canter, H.G., and Luchsinger, P.C.: Effect of a respiratory stimulant on the ventilatory response to carbon dioxide inhalation. Amer. J. Med. 37:386-391 (Sept.) 1964.

The effect of a respiratory stimulant, Emivan, on the respiratory response to carbon dioxide inhalation has been studied in emphysema patients with and without hypercapnia, as well as in a group of normal subjects. A rebreathing technic which allowed gradual progressive increases in inspired carbon dioxide concentration (0 to 5 percent) was used. The ratio of the change in minute ventilation to the change in arterial carbon dioxide tension served as an index of respiratory efficiency. This ratio was found to be 1.48 l./minute/mm. Hg. $PaCO_2$ in persons without any lung disease and was similar to the values obtained by other workers. With the addition of the respiratory stimulant, ventilation was further increased with a proportional change in arterial carbon dioxide tension and hence no change in the ratio. Therefore, in subjects without lung disease and no mechanical restriction to ventilation within the physiologic range, respiratory stimulation has no effect on efficiency of respiration. However, when higher levels of ventilation are achieved the work of breathing and carbon dioxide production become increasingly important limiting factors, even in this normal group. In emphysematous patients with hypercapnia the ratio was low and fell further during drug infusion. This was due to a disproportionate increase in arterial carbon dioxide tension and indicates the adverse effect of respiratory stimulation in patients with an increased work of breathing. - APCA 64-220

256. Dorcus, R.M., and Weigand, G.E.: The effect of exhaust gas on the performance in certain phychological tests. J. General Psychol. 2: 73-96 (Jan.) 1929.

Authors state that the increase in the number of automobiles and trucks and the accompanying increase in the exhaust gas caused thereby has given rise to some new physiological and psychological problems. These problems involve both the immediate and the cumulative effects upon the human organism.

In order to ascertain such effects, six medical students were exposed daily to exhaust gas for a period ranging from about 3-1/2 to 6 hours, except for certain control days.

The psychological tests employed in this investigation were steadiness, tapping, dynonometer, substitution, arithmetic, location memory, and the so-called Felix test. In the summary, authors state that it might be concluded that no significant difference in performance was found after exposure to exhaust gas-air mixtures which contained 2, 3, and 4 parts of CO per 10,000 of air for periods ranging from 3 to 5 hours and which caused 25 to 35 per cent of the hemoglobin to be in combination with CO. Although there was a slight tendency for a poorer performance to be made on the prolonged steadiness test, the difference in performance on all the other tests used was no greater than the variation in performances on successive control periods.

The necessity for more work in this area is emphasized. - AGC

257. Forbes, W.H., Dill, D.B., de Silva, H., and Van Deventer, F.M.: The influence of moderate carbon monoxide poisoning upon the ability to drive automobiles. J. Indust. Hyg. 19:598-603 (Dec.) 1937.

This paper reports the procedures and findings of what is probably the best research study on this subject so far conducted. Tests were made on eight normal male subjects with various percentages of carbon monoxide in the blood. These included measurement of the time required to remove the foot from the accelerator and the time to push down a brake pedal after a red light was flashed on; depth perception; ability to see dim objects at the side of a bright light; ability to perceive the approach or recession of objects; accuracy of steering.

These investigators found that the test performance was unaffected at a carboxyhemoglobin saturation level of 25% and was not disturbed until 30% was reached. The present investigators note that this value appears high as compared to present day concepts but observe that this study gives every impression of having been conducted with a high degree of competency. - PHS-RG 5676

258. Hanson, J.S., and Tabakin, B.S.: Steady state carbon monoxide diffusing capacity in normal females. J. Appl. Physiol. 16:839-841 (Sept.) 1961.

The diffusing capacity of the lung for carbon monoxide was determined in 100 normal females age 20-60 years during steady state treadmill exercise. Values obtained were compared with a corresponding study in males, and it was established that when body surface area is taken into account there is no significant sex difference in Dl_{co}. No significant decrease in diffusing capacity was seen with advancing age. Normal mean values and limits of normal for the various age groups are given. - Authors' Abst.

259. **Henderson, Y., Haggard, H.W., Prince, A.L., and Teague, M.C.: Ventilation of vehicular tunnels. Part II. Physiological effects of exhaust gases from motor vehicles. J. Amer. Soc. Heating & Ventilating Eng. 32:153-158 (March) 1926.**

Standards for the ventilation of tunnels, which will greatly reduce the expense of ventilation below that of 1 to 10,000 dilution, are proposed in this paper. Since traffic through the Holland Tunnel consists of passenger cars which take 10 to 12 min. for the trip, and trucks taking 35 to 40 min., the standards worked out afford according to the authors, absolute safety and freedom from any trace of discomfort for healthy and vigorous adults exposed for a period of 45 to 60 min. to CO. Thirty-nine experiments involving nine men and one woman, using a six-cubic meter chamber are described. The essential practical results of this investigation is summed up in a diagram which shows the rate at which CO may be absorbed, and the amounts at which physiological effects may occur. The curves are drawn to show the rate of absorption of CO when air with various concentrations from one to seven parts of CO in 10,000 is breathed. They express the absorption by the blood during one hour of half the amount of CO that would be taken up after a prolonged stay in each of these atmospheres. - AGC

260. Killick, E.M.: The nature of the acclimatization occurring during repeated exposure of the human subject to atmospheres containing low concentrations of carbon monoxide. J. Physiol. (London) 107: 27-44, 1948.

A single human subject was repeatedly exposed to low concentrations of CO in an airtight chamber; each exposure was prolonged until the COHb% attained a steady value.

The degree of acclimatization was indicated by (a) the diminution in severity of the symptoms during successive exposures to the same concentration of CO, (b) the discrepancy between the observed COHb% at the end of an exposure, and the COHb% obtained in vitro when the subject's blood was equilibrated with a mixture containing O_2 and CO at the same partial pressure as in the alveolar air.

Acclimatization was not accompanied by changes in the red-cell count, in the proportion of reticulocytes, or in the blood volume.

The results of inhaling a measured volume of CO from a closed-breathing circuit confirmed the existence of acclimatization, and demonstrated that no appreciable destruction of CO occurred in the body.

The value of the constant for the partition of Hb between O_2 and CO, as determined in vitro, remained unaltered as acclimatization developed.

A possible explanation of these results is discussed. - Author's Sum.

261. Pace, N., Consolazio, W.V., Pitts, G.C., and Pecora, L.J.: The rate of blood absorption of low concentrations of carbon monoxide in ambient air at simulated altitudes up to 10,000 feet. NMRI Project X-417, Report No. 2, Aug. 31, 1944.

Tests of 3 to 5 hours' duration were conducted at a simulated altitude of 10,000 feet (520 mm. Hg), in which subjects breathed CO concentrations of 0.87 parts/10,000 and 1.79 parts/10,000 by means of a demand system and A-14 mask. Analyses of "arterialized" blood withdrawn from veins of the heated hand, and measurements of pulse rate and respiratory minute volume were made. The altitude decrement attributable to the presence of given amounts of COHb was not ascertained. This problem is now being studied.

The results of these tests permit the following statements:

At the end of 5 hours' exposure at 10,000 feet, the inhalation of 1.79 parts/10,000 CO was accompanied by an uptake of not more than 12 per cent COHb.

The rate of uptake of CO follows a predictable course in a range of concentrations from 0.87 parts/10,000 to 20 parts/10,000.

The blood level of COHb may be predicted over the range by the equation:

$$\Delta \%\text{COHb} = \frac{\text{Parts CO x Corr. Min. Vol. x Time}}{\text{42.5 x Blood Vol.}}$$

The effect of altitude is taken into account by correcting the minute volume of respiration, as measured at altitude, to STP.

The experimental data show close agreement with calculations based on theoretical values obtained by means of the equation.

The time of exposure required to reach a given blood level of COHb in relation to the CO concentration in ambient air can be computed within the limits of experimental error for sea level, and for various altitudes up to 10,000 feet.

A summary of the data obtained in this study was prepared for limited distribution as Report No. One. - Authors' Sum.

262. Pace, N., Consolazio, W.V., White, W.A., Jr., and Behnke, A.R.: Formulation of the principal factors affecting the rate of uptake of carbon monoxide by man. Amer. J. Physiol. 147:352-359, 1946.

The rate of uptake of carbon monoxide has been shown to be constant with respect to blood concentration of COHb, up to values of one-third the equilibrium level, when air containing CO in the range 1 part to 20 parts per 10,000 is breathed by men at rest or engaged in moderate physical activity.

An equation has been derived which serves as a means of estimating in man the degree of blood saturation with CO as a result of exposure to air containing this gas as follows:

$$\Delta \text{ per cent COHb} = \frac{\text{Parts CO X Minute Volume X Exposure Time}}{\text{46.5 X Blood Volume}}$$

The equation is valid for values of per cent COHb up to one-third the equilibrium value for the air concentration of CO under consideration. Within this range Δ per cent COHb may be estimated within a degree of error whose standard deviation is ± 2.3 per cent COHb.

The fraction of CO removed from the inspired air by the blood was found to be constant as uptake progressed, and the mean for a group of twelve men was 41.2 per cent with a standard deviation of ±4.4 per cent. This value is somewhat lower than that observed by previous investigators. - Authors' Sum.

263. Sayers, RR., Yant, W.P., Levy, E., and Fulton, W.B.: Effects of repeated daily exposure of several hours to small amounts of automobile exhaust gas. USPHSB No. 186, 1929, 58 pp.

Six men were exposed in a chamber from 4 to 7 hours daily, for 68 days, to gasoline engine exhaust containing 200, 300, and 400 ppm of carbon monoxide. At 200 ppm, carboxyhemoglobin reached 25 percent in 5 or 6 hours; more than one-half the subjects experienced no symptoms at all, the remainder suffering slight discomfort in 2 hours and frontal headache in 4 hours. At 300 ppm and at 400 ppm, carboxyhemoglobin reached 30 percent, within 5 and 4 hours respectively. At the higher concentration, more than 90 percent of subjects suffered frontal headache within 4 hours, and a few complained of occipital headache. No deleterious effects upon health or well-being were detected, and psychologic examination revealed only a slight tendency to poorer performance in the prolonged steadiness test. A definite increase in hemoglobin and red blood cell count was noted. - Sch, p. 122

264. Schulte, J.H.: The medical aspects of closed cabin atmosphere control. Military Med. 126:40-48 (Jan.) 1961.

One hundred and eight healthy adult males between the ages of 17 and 37 years were exposed in an operating nuclear submarine to an atmosphere with an average consistency of 19.7% oxygen, 1.04% carbon dioxide, 1% hydrogen, 44 ppm carbon monoxide, 15 ppm freon-12 and approximately 78% nitrogen continuously for 72 days. The atmosphere occasionally contained small amounts of ammonia, chlorine and aromatic hydrocarbons. Presumably other contaminants were also present in trace amounts.

The physiological and metabolic evaluations which were studied during the 72 day exposure consisted of the general health, vital signs, blood cell determinations, exercise tolerance, caloric requirements, and dietary habits. Using these criteria, no changes occurred which are attributable to exposure to the existing atmosphere and no harmful effects were elicited either during or shortly following the exposure. - Author's Sum. Modified

265. Von Post-Lingen, M.L.: The significance of exposure to small concentrations of carbon monoxide. Results of an experimental study on healthy persons. Proc. Royal Soc. Med. 57(Part II):1021-1029 (Oct.) 1964.

The investigations being reported were carried out, between 1955 and 1958, at the National Institute of Public Health in Stockholm.

Observations ere made of the reactions of healthy persons to carbon monoxide concentrations which do not generally cause subjective disturbances, i.e., which produce carboxyhemoglobin (COHb) blow 25%. The reactions were evaluated by means of flicker fusion tests and Evipan tolerance tests. An ordinary Krogh spirometer of the type used in measuring basal metabolism, was used. In this closed rebreathing system the concentrations of CO ranged from 0.35 to 2.13 volumes %, with a duration of exposure of about 7 minutes. The results of the experiments showed that: (1) Daily inhalation of CO for four weeks, producing COHb of 10-11%, gave rise to a cumulative effect which was manifest as latent impairment of the ability to distinguish between light flashes in rapid succession. (2) Daily inhalation of CO producing 6-7% or 10-11% COHb caused increase of sensitivity in some persons and reduction of sensitivity in others. The increased sensitivity subsided during the following months and had disappeared after a year. The modifications of sensitivity were more pronounced when the daily tests gave 6-7% COHb for eight weeks than when the COHb was 10-11% for four weeks. The author discusses the differences in his findings and those reported by Lindgren (1961) on occupational exposure to CO with special reference to "chronic CO poisoning." - APCA 64-270

266. Young, W.A., Shaw, D.B., and Bates, D.V.: Effect of low concentrations of ozone on pulmonary function in man. J. Applied Physiology, 9, 4, 765-768 (July) 1964.

Describes results of measurements of pulmonary function made on 11 subjects in 16 experiments breathing ozone (0.6-0.8 ppm) through mouthpiece for 2-hour periods. Ozone produced highly significant reduction in steady-state DL_{CO} (diffusing capacity of lung for carbon monoxide). Vital capacity and expiratory flow rates may be limited in part by tracheobronchial irritation that follows inhalation of 0.6 ppm of ozone for 2 hours. - CBK

Biochemistry and Biophysiology

267. Ambrosio, L., and Mazza, V.: Immunological potency in carbon monoxide intoxication. III. Behavior of the antistreptolysin titer. Riv. istituto sieroterapico ital. (Naples) 34:399-405 (Sept.-Oct.) 1959.

The behavior of the antistreptolysin (a.s.) titer in 12 dogs, divided into 3 groups, was investigated. Group 1 inhaled for 4 hours daily 1% (?) carbon monoxide for 40 days; group 2 was similarly treated and vaccinated with streptococcal vaccine; group 3 received vaccine only. In the CO-treated animals (group 1) the a.s. titer was not different from the values at the beginning of the experiment; vaccination of group 3 animals brought about a progressive increase of the a.s. titer up to a maximum value of 500 units, while vacinated and CO-intoxicated group 2 animals showed a lower antibody response with a maximum value of 125 units.

It is suggested that the lower immune response of group 2 animals is associated with the alteration of plasma protein composition caused by CO intoxication. - APCA 4254

268. Anson, M.L., Barcroft, J., Mirsky, A.E., and Oinuma, S.: On the correlation between the spectra of various haemoglobins and their relative affinities for oxygen and carbon monoxide. Proc. Royal Soc. London 97:61-83, 1924-1925.

A convenient calibration of the Hartridge reversion spectroscope is described.

For a number of different mammals the following relationship exists. If A be the position of maximum intensity of the a-oxyhaemoglobin spectral band, B that of CO haemoglobin, and K the equilibrium constant of the equation

$$CO + HbO_2 \rightleftarrows COHb + O_2$$

$$\text{Log } K = 0.05\ (A - B),$$

A and B being measured in Angstrom units.

Log K is a measure of the change in free energy involved in the reaction.

The value of (A — B) called in the paper "the span," varies from 43 to 56 Angstrom units in the mammals which we have observed. The variation in individuals in the same species is very marked.

The relation stated in § 2 is true of the recrystallised haemoglobins.

The cause of variation seems to lie rather in the specificity of the globin portion of the molecule than in the haematin portion.

Brown and Hill's observations on the effect of temperature on blood have been treated along similar lines. The reaction being taken as

$$Hb_n + nO_2 \rightleftarrows (HbO_2)_n .$$

If at temperatures T_1 and T_2, C_{T_1} and C_{T_2} represent the concentrations of oxygen in solution when the haemoglobin is half saturated in each case, and A_{T_1} and A_{T_2} represent the position of maximum intensity of the a-bands,

$$\text{Log } \frac{1}{C_{T_1}} - \log \frac{1}{C_{T_2}} = .049\ (A_{T_1} - A_{T_2}).$$

- Authors' Sum.

269. Asmussen, E., and Chiodi, H.: The effect of hypoxemia on ventilation and circulation in man. Amer. J. Physiol. 132:426-436, 1941.

Respiration. Our experiments have shown that hypoxemia caused by partial CO-poisoning (20-30 per cent) (anemic hypoxemia) elicts little or no respiratory response whereas hypoxemia caused by an alveolar pO_2 of about 40 mm. Hg (hypoxic hypoxemia) causes a very pronounced hyperventilation both in rest and in work.

It is concluded: 1. General O_2-lack in the tissues does not evoke a hyperventilation. 2. The O_2 tension of the arterial blood, and not its O_2 content, is the active factor in causing hyperventilation. 3. The effect is produced through the pO_2 of the carotid body (glomus).

Circulation. Our experiments have shown that both in rest and during work a state of hypoxic hypoxemia, with the O_2 in the inspired air low enough to reduce the arterial HbO_2 to 70 to 80 per cent, produces an increase in cardiac output above the normal. Furthermore, both in rest and during work a state of anemic hypoxemia (20-30 per cent Hb saturated with CO) has little or no effect on the cardiac output, but increases the pulse rate considerably.

It is concluded: 1. Acute O_2-lack in the tissues is not a stimulus for the circulation. 2. A lowered O_2 tension of the arterial blood, not a lowered O_2 content, is a stimulus for the circulation. 3. The effect probably is produced through the chemoreceptors of the carotid glomus. - Authors' Sum.

270. Bacaner, M.: Physiologic process in absorption of pollutants. Arch. Environ. Health 8:77-85 (Jan.) 1964.

This is a short discussion of the physiologic mechanisms in the handling of absorbed pollutants. A few specific examples (carbon monoxide among those mentioned) are cited to illustrate the problem involved.

Author points out that a true estimation of body burden for any individual pollutant requires comprehensive study of multiple parameters. - AGC

271. Bernhard, W.F.: Hyperbaric oxygenation. New England J. Med. 271: 562-564 (Sept. 10) 1964.

Author states that although the data may suggest that hyperbaric oxygenation is of value in the management of three specific classes of diseases, for example, carbon monoxide intoxication, extrapolation to other areas of clinical medicine does not seem warranted. Instead, it is hoped that these investigations will stimulate the pursuit of basic problems in hyperbaric physiology, so that with time, improved methods for the management of other disease processes may be found. Author's Conclusion Modified-AGC

272. Campbell, J.A.: Comparison of the pathological effects of prolonged exposure to carbon monoxide with those produced by very low oxygen pressure. British J. Exp. Pathol. 10:304-311, 1929.

It is shown that in chronic carbon monoxide poisoning in animals the pathological effects resemble very closely those of prolonged exposure to very low oxygen pressure in the inspired air; the main changes are venous congestion with atrophy of certain cells (e.g. liver, heart muscle near epicardium), oedema and dropsy indicating that heart failure is the cause of inability to tolerate prolonged exposure to carbon monoxide. The organs showing most marked congestion and its sequelae are the liver, lungs, heart muscle near epicardium and the brain. Haldane's view that carbon monoxide acts purely by interfering with the oxygen supply to the tissues is supported.

Power to tolerate carbon monoxide--just as in the case of low oxygen pressure in the air--depends upon the ability of the vital organs, particularly the heart, to continue to function under a low tissue oxygen tension; tissue oxygen tension is not brought back to normal level by so-called acclimatization under severe degrees of oxygen want. - Author's Sum.

273. Carlsen, E., and Comroe, J.H., Jr.: The rate of uptake of carbon monoxide and of nitric oxide by normal human erythrocytes and experimentally produced spherocytes. J. General Physiol. 42:83-107 (Sept.) 1958.

An in vitro study was made of the uptake of carbon monoxide and nitric oxide by normal human erythrocytes and by similar erythrocytes altered by treatment either with heat or with immersion in hypotonic or hypertonic saline solutions. The initial overall rate of gas uptake was measured with a modified version of the Hartridge-Roughton-Milikan rapid-reaction-constant-flow apparatus. As the chemical combination of nitric oxide with hemoglobin is extremely rapid, uptake measurements included only diffusion across the cellular membrane and intraerythrocytic diffusion. Results show that human biconcave discoidal erythrocytes at 38 and 48°C. have the same initial rate of carbon monoxide and nitric oxide uptake as the same cells changed to spherical form by heating (no change in volume) or by treatment with a hypotonic solution (a 30% increase in cell volume). Similar cells, changed to crenated spheres and reduced in volume by treatment with a hypertonic solution, showed a marked decrease in the gaseous uptake rate of the dehydrated cells. - APCA 2068

273a. Coscia, G.C., Perrelli, G., Gaido, P.C., and Capellaro, F.: The behavior of glutathione, stable glutathione, and glucose-6-phosphate-dehydrogenase in subjects exposed to chronic inhalation of carbon monoxide. Rass Med. Indust. 33:446-451 (May-Aug.) 1964.

The authors have studied the behaviour of glutathione and glucose-6-phosphate-dehydrogenase of the red globules in a group of 19 subjects who had been given supraliminal inhalations of CO. In 6 subjects with COHb above normal, a decrease of the GSH proportion was found while the G-6-P-DL was decreased in 6 cases. All the same the comparison of the average values obtained with those of a group of normal subjects did not bring to light statistically significant differences. - Authors' Sum.

274. Dales, S., and Fisher, K.C.: The effect of carbon monoxide on oxygen consumption, glucose utilization, and growth in mammalian cells in vitro. Canadian J. Biochem. Physiol. 37:623-638 (May) 1959.

The effect of carbon monoxide on respiration, growth, and carbohydrate metabolism of Earle's L strain cells was investigated. The rate of gas uptake by suspensions of cells in a Warburg respirometer was the same from mixtures containing various proportions of $CO/O_2/N_2$ or containing only O_2/N_2. Apparently carbon monoxide was not inhibiting oxygen consumption. In respirometers filled with carbon monoxide and oxygen in the ratio of 9:1, illumination caused the net gas uptake to rise 23% above that of the controls. This suggests that the rate of oxygen consumption in the dark was reduced as a consequence of an inhibition of a respiratory enzyme by carbon monoxide. In keeping with this suggestion, a spectroscopic examination revealed the presence in L cells of absorption bands corresponding to those of the cytochrome enzymes. Using differential manometers it was established for the first time that carbon monoxide is taken up by L cells in the dark. It is concluded that a fraction of the gas uptake which is represented by the consumption of oxygen associated with normal metabolism must be reduced in the presence of carbon monoxide. It is also concluded that L cells oxidize carbon monoxide to carbon dioxide. The rate of multiplication of cells was reduced by carbon monoxide while the rate of glucose breakdown and lactic acid production were markedly accelerated, suggesting that there was inhibition of cytochrome oxidase. Low partial pressures of oxygen also reduced the rate of multiplication of L cells while increasing the rate of glucose disappearance and the rate of lactic acid production. The observations reported here thus emphasize the role of aerobic oxidations in the maintenance of the maximum rate of growth. - Authors' Abst.

275. Datsenko, I.I.: The effect of aero-ionization on animals in CO intoxication. Hygiene & Sanitation (Trans. Gigiena i Sanitariya) 29:124-125 (Aug.) 1964, CFSTI - TT65-50023/8.

Intoxication of laboratory animals with carbon monoxide results in a decrease of activity of the cholinesterase of blood serum. This can be used as a sensitive index of the degree of poisoning. Changes in the animals under chronic intoxication with carbon monoxide are persistent, as demonstrated by the incomplete restoration of the activity of cholinesterase three months after the inspiration of CO had been stopped. The use of air ionization had a favorable effect on the organism with regard to conditions of the action of carbon monoxide on the body. - APCA 64-323

276. Datsenko, I.I.: Disturbances of carbon metabolism in experimental carbon monoxide intoxication. Gigiena i Sanitaria 30:30-34 (May) 1965.

The article contains the results of quantitative analyses of sugar in the blood of animals in a glucose test after introduction of adrenalin and insulin under conditions of a prolonged action of various concentrations of CO. In chronic poisoning concentrations of this gas within the limits of 0.012-0.018 mg/l in the inhaled air produced changes in the glycemic curves. These data may serve as an early diagnostic sign of intoxication, besides. They substantiate the necessity of decreasing the maximum permissible concentration of CO in the air. - Author's Abst.

277. Feldstein, M.: The colorimetric determination of blood and breath carbon monoxide. J. Forensic Sc. 10:35-42 (Jan.) 1965.

A colorimetric procedure for the accurate determination of carbon monoxide in air and in combustion effluents has been adapted to the determination of carbon monoxide in blood and breath samples. The method is based upon the reaction of carbon monoxide with an alkaline solution of the silver salt of para sulfaminobenzoic acid. The adsorbence of the resulting colloidal solution of silver is measured spectrophotometrically and is proportional to the concentration of carbon monoxide present in the gas sample. Concentrations of CO from 5 ppm to 1800 ppm can be measured with an accuracy of 95 ± 5%. This corresponds to 5 ppm directly for breath samples, and 0.04 volume % for a 1 ml. sample of blood. - APCA 65-96

278. Ito, M.: The effect of the inhalation of carbon monoxide on the estrus cycle of rats. J. Sc. Labour (Tokyo) 36:496-507 (Sept.) 1960.

The estrus cycle of rats exposed to carbon monoxide was investigated by the vaginal smear method. Of 14 female rats, 9 were exposed to 2% CO for 2 hrs. a day for 8 weeks and the other 5 were used as control animals. The vaginal smear was taken daily by cotton pledget for a period as long as 12 weeks. The exposure to CO caused disturbance of estrus cycle as shown in a figure in the text. It seems to be noteworthy that the stage of initial repression due to the exposure to CO was followed by the state of adaptation, when the rats were exposed to CO repeatedly. The results of the experiments by the present author seem to confirm the pattern of disturbance of estrus cycle observed by other authors. Besides, it attracted the author's attention to the fact that the effect of exposure to CO upon body-weight growth and respiratory metabolism was more evident in animals which showed marked initial repression of estrus due to exposure. This fact seems to suggest that the disturbance in estrus cycle should be regarded as a manifestation of polyglandular impairment due to stress. - APCA 4396

279. Joels, N., and Neil, E.: Carotid chemoreceptor response to high carbon monoxide tension. J. Physiol. 156:5P-6P (Abstract), 1961.

The combination of as much as 80% of the blood haemoglobin with CO causes no carotid chemoreceptor discharge in cats breathing 1-2% CO in air, providing that the arterial pO_2 be not lowered (Duke, Green

& Neil, 1952). The glomus cells normally betray a high oxygen usage (9ml./100 g/min). Their blood flow of 2000 ml./100 g/min (Daly, Lambertsen & Schweitzer, 1954) is, however, so high that they have little difficulty in extracting their large oxygen requirements without causing much fall in the local blood pO_2. Anoxic anoxia disrupts their oxidative metabolism, whereupon the chemoreceptor nerves display a vigorous impulse traffic. Cyanide also causes chemoreceptor discharge, and Anitschkov (1951) has assumed that the drug acts by inhibiting cytochrome oxidase. Cyanide, however, inhibits many of the enzymes which aid carbohydrate metabolism. Only carbon monoxide exerts a specific inhibition of cytochrome oxidase (Dixon & Webb, 1958). The affinity of cytochrome oxidase for CO is less than that for O_2. Thus it is necessary to use high CO tensions locally in glomus circulation in order to ascertain whether chemoreceptor discharge ascribable to cytochrome oxidase inhibition can be aroused.

Two sets of experiments were performed on cats anaesthetized with pentobarbitone.

1-2 ml. of blood (pCO = 300-500 mm, pO_2 = 150 mm, pCO_2 = 40 mm Hg) was injected locally into the carotid glomus circulation. Transient hyperpnoea and hypertension which occurred was abolished by cutting the relevant sinus nerve.

Electroneurography of chemoreceptor fibres showed that vigorous impulse activity was aroused by the perfusion of solutions equilibrated with pCO 300-500 mm Hg and normal pO_2 and pCO_2.

The inhibition of cytochrome oxidase thus does mimic the effect of anoxic anoxia on the glomus cells. It must be stressed that CO is used here as a biochemical tool; ordinarily in CO poisoning the tissue pCO is far too low to exert such histotoxic effects. - Authors' Abst.

280. Konecci, E.B., Taylor, W.F., and Wilks, S.S.: Biological and medical aspects of ionizing radiation: Protective action of carbon monoxide in mammalian whole-body x-irradiation. USAF School of Aviation Med. Rep. No. 55-8, March, 1955.

The present study was designed to test the possible prophylactic and therapeutic usefulness of carbon monoxide in mammalian whole-body x-irradiation. Guinea pigs, rats, and rabbits were utilized in a variety of treatments. CO was administered either by inhalation (0.10 percent CO) or intraperitoneal injection (100 percent CO). Whole-body x-irradiation was performed with a Picker x-ray unit (260 KVP, 18 ma.), and all of the statistically treated animals were exposed to lethal doses of x-rays.

Protection occurred in pre- and/or post-irradiated, CO-treated animals to different degrees. Experiments indicate that CO protection depends on (1) optimal amounts of CO inhaled or injected, (2) critical times of CO administration pre- and/or post-irradiation, and (3) dose of whole-body x-irradiation. Possible modes of protection afforded by carbon monoxide are discussed. - Authors' Abst.

281. Medaglini, E. : Studies on the urinary elimination of 17-ketosteroids and 17-hydroxycorticosteroids in persons affected with chronic intoxication from carbon monoxide. Ras. Neuropsichiat. (Salerno) 16:55-58, 1962.

The author studied the elimination of the 17-ketosteroids and of the 17-hydroxycorticosteroids in the urine of each of a group of persons following chronic exposure to carbon monoxide. The studies revealed a diminished elimination of the substances during the period of intoxication with a gradual return to normal of the adrenal functioning in direct relationship to the improvement of the total clinical picture. - APCA 5103

282. Mosinger, M., and Rochette, J.: Histological reactions of the lungs after inhalation of certain anesthetics and toxic gases. Zentralblatt der Gewerbehygiene und Unfallverhütung 27:227, 1940.

Guinea pigs were subjected for varying periods of time to the inhalation of ethylene oxide and chloride and carbon monoxide and to the action of cold (3°-4° F.). Circumscribed areas of emphysema and atelectasis were more pronounced after long inhalation of ethylene oxide than with the other gases studied. Necrosis of the bronchial epithelium occurred only after chloride inhalation. Vasodilatation was present also. Interalveolar edema was also slight after inhalation of ethylene oxide and carbon monoxide, very severe after chloride inhalation, and pronounced after exposure to cold. Peribronchial edema occurred only after chloride inhalation. Alveolar edema appeared early after inhalation of chloride and carbon monoxide and late after ethylene oxide inhalation of chloride and carbon monoxide but was not otherwise observed. The appearance of mitoses in the alveolar epithelium and capillary epithelium was found only after the inhalation of ethylene oxide. The desquamation of the alveolar epithelium, which has been considered characteristic for war gases and anesthetics, was noted also after the action of carbon monoxide; it is therefore not characteristic, at least in the guinea pig. - BMB 934

283. Navrotskii, V.K.: Immunobiological reactivity as a method of determination of the maximum permissible concentration of harmful chemical substances in the air of closed premises. Gigiena i Sanitaria 25:29-33 (June) 1960.

The agglutination titer after immunization with typhoid fever vaccine proved to be a very sensitive test for evaluating the reactivity of rabbits during chronic poisoning with small concentrations of carbon monoxide, sulfur dioxide gases, and vapours of aviation benzene. - APCA 4262

284. Pecora, L., Fati, S., and Vecchione, G.: Free erythrocytic protoporphyrins and urinary coproporphyrins in experimental and clinical CO poisoning. Folia Med. 40:213-226, 1957.

The behaviour of the free erythrocytic protoporphyrins and urinary coproporphyrins has been studied.

The erythrocytic protoporphyrins increase constantly and remarkably nearly immediately afterwards the poisoning and the disorder continues for many hours.

The daily repeated poisoning induces a progressive standing increase of the rate of the protoporphyrins and the urinary coproporphyrins.

This finding proves a direct action of poison on the metabolism of the porphyrinic pigments, and the pathogensis will be studied furthermore. - Authors' Sum.

285. Pecora, L.J.: Physiologic study of the summating effects of ethyl alcohol and carbon monoxide. Amer. Indust. Hyg. Ass. J. 20:235-240 (June) 1959.

No significant summating effects of alcohol and carbon monoxide were noted in a physiologic study made using 3 groups of dogs. One group received only alcohol, another CO alone and the 3rd both alcohol and CO. The blood alcohol level, confirmed by analysis, was kept at over 0.15 volume % during the daily exposure to 0.01% CO for 6 hours/day, 5 days/week for 21 weeks. The expected level of COHb, between 18 and 20%, after exposure to 0.01% CO for several hours was obtained. The hemoglobin concentration was in the normal range for 3 groups. The alcohol-carbon monoxide group had a mean value of 18.2% COHb while the group on CO alone had a mean value of 20.8%. The Hb mean group values were 14.4 and 14.8 g./100 respectively. The bromsulphalein liver function test was negative and the electrocardiograms were essentially normal during the whole experiment. No observable neurologic abnormalities were noted. Body temperature was normal during the whole test. Histologic study did not reveal any differences between groups nor were there any remarkable changes. A single electrophoretic assay of serum protein and lipoprotein showed a marked decrease in total lipoprotein due chiefly to reduced fraction. - APCA 2636

286. Prokhorov, I͡U.D., and Rozov, A.A.: The pathohistological and histochemical changes in the organs of rabbits subjected to a prolonged action of carbon monoxide, sulfur dioxide, and their mixtures. Gigiena i Sanitaria (Moscow) 24:22-26 (June) 1959. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 5, 1960, pp. 81-86, CFSTI-TT-61-11149, U.S. Dept. of Commerce, Springfield, Va.

Histological and histochemical changes have been studied in the organs of rabbits subjected for a period of 3 months to poisoning with carbon monoxide at concentrations of 0.2 and 0.4 mg./l., with sulfur dioxide at 0.2 mg./l., and with mixtures of both gases. The author has noted vascular disturbances, dystrophic lesions in the internal organs, a fall in the activity of the succindehydrase (succino-dehydrogenase?) due to the effect of sulfur dioxide and a more pronounced change produced by the same concentration of sulfur dioxide in the presence of carbon monoxide. In the presence of carbon monoxide at a concentration of 0.2 mg./l. the activity of succindehydrase was observed to increase and this could be regarded as a compensatory effect. - APCA 3100

287. Pukhov, V.A.: The influence of adrenal cortex insufficiency and hyperfunction on the sensitivity of rats and mice to carbon monoxide poisoning. Farmakol. Toksikol. 27:343-345 (May-June) 1964.

Result of experiments made on rats and mice showed that after removal of adrenals the animals showed increased sensitivity to carbonic oxides after one week. During the first two weeks after the transplant took place there was still sensitivity to CO. However after one month the resistance was again about the same as before the transplant took place. The ACTH administered to the mice in doses of 0.2 Un/kg for a period of 7 days increased the resistance to CO. - Author's Abst.

288. Root, W.S., Allen, T.H., and Gregersen, M.I.: Simultaneous determinations in splenectomized dogs of cell volume with CO and P^{32} and plasma volume with T-1824. Amer. J. Physiol. 175:233-235, 1953.

Blood was removed from splenectomized dogs and separate portions were labeled with CO and P^{32}. The tagged cells were then injected into the same dog in order to measure the cell volume with the two methods simultaneously. At the same time plasma volume was measured with T-1824.

In 10 dogs the results show that the cell volume measured with CO is 12% greater than that measured with P^{32}-labeled cells, indicating that distribution of CO includes more than the circulating cell volume. The possibility is considered that the difference in the estimates of cell volume with CO and P^{32} may be a useful index of changes in erythropoietic tissue. - Authors' Sum.

289. Rossi-Fanelli, A., and Antonini, E.: Studies on the oxygen and carbon monoxide equilibria of human myoglobin. Arch. Biochem. 77:478-492, 1958.

A new spectrophotometric method of determining the oxygen-dissociation curves of Mb (and Hb) has been developed.

The oxygen equilibrium of human crystallized Mb has been studied by this method. The effect of temperature, pH, ionic strength, and concentration of the pigment has been examined.

The oxygen-dissociation curves of reconstituted Mb's and of Mb components Mb I and Mb II have also been investigated.

The partition constant K = (MbCO) X P_{O_2}/(MbO_2) X P_{CO}, for human crystallized Mb has been determined. - Authors' Sum.

290. Roughton, F.J.W.: The kinetics of the reaction $CO + O_2Hb \rightleftarrows O_2 + COHb$ in human blood at body temperature. Amer. J. Physiol. 143:609-620 (April) 1945.

Measurements are given of the velocity with which CO displaces O_2 from combination with human hemoglobin in solution and in unlaked red cells at 37° C.

The kinetic data conform to the same equation as has been established for sheep hemoglobin solution at 10 to 20° C., namely,

$$\frac{d(COHb)}{dt} = \frac{m'(CO)(O_2Hb)}{O_2} - m(COHb)$$

At (O_2) values of 0.6 mM and over, the value of m', i.e., 21.0, is within error the same for hemoglobin in solution as in the red cell. This indicates that at high (O_2) values diffusion through the membrane and substance of the red cell has no limiting effect on the velocity of the overall reaction. At lower (O_2) values theoretical calculations suggest that the rate in the red cell would be less than in solution but this has not yet been experimentally verified.

The value of m at 37° C. is 0.1. The time for half dissociation of human COHb is thus 6.9 seconds in the body.

A minimum value for the permeability of the red cell membrane to O_2 is given.

The kinetic data of this paper are available for several physiological problems such as the rate of uptake and output of CO from the human body and the calculation of the average time spent by the blood in the lung capillaries. - Author's Sum.

291. Schütze, W.: On the danger for man and animal from high concentration of some toxic gases through the skin. Archiv fur Hygiene und Bakteriologie 98:70-83, 1927.

The results of animal tests show that also high concentrations of CO are not absorbed through the skin. - AGC

292. Shtrum, I.Ya.: The combined action of carbon monoxide and hydrogen sulfide. J. Physiol. U.S.S.R. 24:624-629, 1938.

Author found no evidence of summation or potentiation between hydrogen sulfide and carbon monoxide upon the reflex time of rabbits or the mortality of mice and concluded that "incomplete summation" occurs: that because hydrogen sulfide produces tissue anoxia, the anoxemia of carbon monoxide is less injurious than it would otherwise be because the tissues no longer require their full quota of oxygen. - Sch 201, p. 123

293. Sjöstrand, T.: Endogenous formation of carbon monoxide in man. Nature 164:580-581 (Oct. 1) 1949.

When determining the carboxyhaemoglobin concentration by analysing the concentration of carbon monoxide in the alveolar air according to a method described earlier, it has been observed that a low concentration of carbon monoxide is present invariably in the alveolar air in man. To investigate this observation, it was necessary (1) to determine whether it really is carbon monoxide that gives the effect with the indicator used, and (2) to endeavour to show whether the presence of this factor in the alveolar air is due to carbon monoxide absorbed from the atmospheric air or to endogenous formation.

The observations so far made seem to show that small quantities of carbon monoxide are constantly being formed in the human body and are emitted with the expiratory air; this endogenous carbon monoxide formation increases considerably in certain pathological conditions with abnormal decomposition of the blood cells. - From Text-AGC

294. Sjöstrand, T.: The formation of carbon monoxide by in vitro decomposition of haemoglobin in bile pigments. Acta Physiol. Scandinav. 26:328-333, 1952.

Solutions of crystalline horse haemoglobin were incubated at 38° C after the addition of ascorbic acid. It was possible to show the formation of CO constantly in conjunction with the appearance of an absorption band at wave length 630 mμ corresponding to the choleglobin (verdoglobin) band.

A linear relation exists between the amounts of CO and choleglobin formed during incubation up to about 24 hours.

When incubation is carried on for a longer time, the CO formation continues in linear relation to the time of incubation up to approximately 200 hours. At this point the absorption band of the haemoglobin has practically disappeared.

The maximal amount of CO obtained during incubation for longer periods corresponds to the CO-binding capacity of the initial haemoglobin solution.

These observations are in agreement with the previously expounded hypothesis that a molecule of CO is liberated when each of the porphyrin rings in the haemoglobin molecule splits. - Author's Sum.

295. Sjöstrand, T.: Formation of carbon monoxide by coupled oxidation of myoglobin with ascorbic acid. Acta Physiol. Scandinav. 26:334-337, 1952.

Solutions of myoglobin have been incubated at 38° C after the addition of ascorbid acid. Consequently there is a manifestation of carbon monoxide and a substance with an absorption band at 640 mμ. The observation coincides with previous observations of the decomposition of haemoglobin, and indicates that myoglobin can decompose in a manner similar to haemoglobin by oxidation of a methene group to CO, which splits. It may be supposed that this reaction also takes place in vivo and contributes to the endogenous formation of carbon monoxide. - Author's Sum.

296. Sjöstrand, T.: The formation of carbon monoxide by the decomposition of haemoglobin in vivo. Acta Physiol. Scandinav. 25:338-344, 1952.

Haemolysed blood and solutions of haemoglobin were injected into dogs intramuscularly, and into human beings and rabbits intravenously in connection with repeated determinations of the alveolar CO concentration or the concentration of CO in exhaled air. From the concentration and volume of CO in expired air, the volume of CO exhaled per minute was determined for a period of 5 to 8 hours after the injection.

It transpired from this that the injection of haemoglobin or haemolysed blood causes an increase in the alveolar CO concentration and the volume of CO exhaled per minute.

The quantitative relation between the increase in CO formation and the amount of haemoglobin that was injected, corresponds to the formation of 4 molecules of CO for each molecule of haemoglobin.

The observations agree with the supposition that a molecule of CO is formed during the splitting of haemochromogen's tetrapyrrole ring. It would seem that the endogenous formation of CO and its variations under normal and pathologic conditions can be explained in this way. - Author's Sum.

297. Sköld, G., and Brunk, U.: Effect of mode of sacrifice on histochemically demonstrable activity of unspecific esterases and unspecific alkaline monophosphatases in golden hamsters. Acta Path. Microbiol. Scand. 61:190-194, 1964.

Recent years have witnessed a surge of interest in the histochemically demonstrable activity of different enzymes and their distribution under various experimental conditions. The purpose of the present investigation was to find out whether the mode of sacrifice of the experimental animals had any effect on the histochemically demonstrable activity and distribution of unspecific esterases and unspecific alkaline monophosphatases. - Authors' Abst.

298. Tiunov, L.A., Sokolova, T.I., and Paribok, V.P.: Duration of carbon monoxide excretion from the body. Farmakol. i. Toksikol. 20:76-78, 1957. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 7, 1962, pp. 262-264, CFSTI-TT-62-11103, U.S. Dept. of Commerce, Springfield, Va.

The authors state that data reported in the literature on the rate of carbon monoxide excretion from the body are contradictory. In this study, the authors investigated the rate of carbon monoxide excretion from the blood and the possibility of its being retained by the tissue, employing the labled atoms method which is being described. Results of this investigation is shown in two tables. - AGC

299. Tiunov, L.A., and Vasil'ev, G.A.: Effect of cytochrome C on radioprotective action of carbon monoxide. Radiobiologiya 3:766-767, 1963. Translation in: Fed. Proc. (Part II):T133-T134 (Jan.-Feb.) 1965.

Cytochrome C, in a dose of 8 mg/kg, does not affect the prophylactic action of carbon monoxide in X-irradiation.

Cytochrome C abolishes the therapeutic effect of carbon monoxide in X-irradiation.

Injection of cytochrome C intraperitoneally in a dose of 8 mg/kg body weight into albino rats 15 minutes before, or after irradiation has no effect on the survival rate of albino rats irradiated in a dose of 730-750 r.

The possible mechanism of this effect of cytochrome C on the radioprotective action of carbon monoxide is discussed. - Authors' Conclusions

300. Williams, L.A., Linn, R.A., and Zak, B.: Ultraviolet absorptiometry of palladium for determination of carbon monoxide hemoglobin. Amer. J. Clin. Pathol. 34:334-337 (Oct.) 1960.

Previous methods for the determination of carbon monoxide hemoglobin have involved the reduction of palladium ions in acid solution to a free metal by means of diffused carbon monoxide. The residual palladium was then reacted with various materials to provide colors that would have absorptiometric properties in the visible light range. Investigations of the spectral characteristics of palladium ions themselves in the ultraviolet portion of the spectrum indicated that this substance had a high molar absorptivity. Thus, the sensitive ultraviolet absorbance of palladium chloride in acid could itself be used to obviate an unnecessary reaction with palladium ions to form a colored complex in a quantitative scheme. In the procedure described, an ultraviolet spectrophotometric determination is made after the excess of palladium ions, which result after reaction of excess palladium chloride with diffused carbon monoxide, have been diluted with hydrochloric acid. The ultraviolet area of the spectrum is much more sensitive for palladium ions than the visible range where the calibration curve is comparatively flat. - APCA 3716

Cardiac Impairment

301. **Beck, H.G., and Suter, G.M.:** Role of carbon monoxide in the causation of myocardial disease. J.A.M.A. 110:1982-1986 (June 11) 1938.

In a group of 136 persons who had been intermittently exposed to carbon monoxide over varying periods, myocardial symptoms were frequently manifested.

The lesions affecting the heart, brain and other organs are primarily vascular, consisting of small hemorrhages and perivascular infiltration with focal necrosis. When the heart is affected, coronary thrombosis frequently develops, as ascertained by postmortem and electrocardiographic studies.

Hemorrhagic lesions affecting the heart muscle have been produced experimentally in animals subjected to varying amounts of carbon monoxide in inspired air.

The impression that unless the patient dies in acute asphyxiation no harm may result is erroneous.

Patients who apparently recover from acute asphyxiation frequently have later manifestations, which appear in from three to seven days. These are known as delayed symptoms, or sequelae, and may affect the heart, brain or other organs and terminate fatally.

Those who survive the delayed manifestations may completely recover or ultimately may have severe organic disease of the heart or of other organs, to which they finally succumb.

Lesions may occur simultaneously in the heart and the brain, as evidenced by clinical studies and post mortem observations.

In order to make a positive diagnosis of chronic myocardial disease resulting from carbon monoxide, it is essential that an accurate history be obtained with respect to exposure to gas, exhibition of symptoms of anoxemia, clinical course of the disease and absence of preexisting cardiac lesions. - Authors' Sum.

302. **Ehrich, W.E., Bellet, S., and Lewey, F.H.:** Cardiac changes from CO poisoning. Amer. J. Med. Sc. 208:511-523, 1944.

Discussed in this paper are acute experiments at 40% carboxyhemoglobin and in chronic experiments at 21% carboxyhemoglobin or an equivalent oxygen deficiency, electrocardiographic and morphologic changes were seen, including inverted T wave, elevated R-T segment, and degenerative changes in individual muscle fibers. When the carboxyhemoglobin exceeded 75% for an hour or more, atrioventricular heart block and myocardial hemorrhage and necrosis supervened. - AGC

303. **Haggard, H.W.:** Studies in carbon monoxide asphyxia. I. The behavior of the heart. Amer. J. Physicl. 56:390-403, 1921.

Death under carbon monoxide asphyxia is due to failure of respiration. This is in the nature of a fatal apnoeavera. The anoxemia resulting from the formation of carboxyhemoglobin induces excessive breathing; and respiratory failure follows the excessive loss of CO_2. Oxygen deficiency caused by carbon monoxide, even in advanced asphyxia is not in itself sufficient to cause impairment of auriculo-ventricular conduction. Following respiratory failure, however, the increased anoxemia from this cause speedily results in the development of heart block through its various stages.

By restoring respiration and rapidly eliminating the carbon monoxide by means of inhalations of carbon dioxide and oxygen, cardiac conduction is restored to normal following the development of block.

The cardio-inhibitory center maintains its activity longer than does the respiratory center. This center is stimulated by the increased C_H which occurs during respiratory failure. From this there results a temporary cessation of auricular activity. This period of inhibition is prevented by the administration of atropine.

When respiratory failure is prevented by means of inhalations of 8 or 10 per cent carbon dioxide, the carbon monoxide combination with hemoglobin rises to an unusually high percentage without any evidence of impairment in a-v conduction. This indicates that there is no direct toxic action of carbon monoxide upon the cardiac conducting system.

Illuminating gas results in an earlier development of respiratory failure than does pure carbon monoxide in corresponding concentration.

Electrocardiographic records are given from two animals which differed from the rest in that one developed a transient period of alternation involving the R and T waves and the other presented, during the time of complete a-v block, a condition resembling auricular fibrillation or flutter. - Author's Conclusion

304. Hayes, J.M., and Hall, G.V.: The myocardial toxicity of carbon monoxide. Med. J. Australia, June 6, 1964, pp. 865-868.

The toxicity of carbon monoxide to the myocardium is well recognized, but reports concerning the mechanism, frequency and electrocardiographic manifestations are not numerous. For this reason, a resumé of the disturbed physiology is presented, together with a small number of case reports, and the therapeutic implications involved are discussed. - Authors' Abst.

305. Hechter, H.H., and Goldsmith, J.R.: Air pollution and daily mortality. Amer. J. Med. Sci. 241:581-588 (May) 1961.

Analysis has been made of the relationship between various environmental factors and daily cardiac and respiratory deaths in Los Angeles County from 1956 to 1958. It was found that the variables, when studied over time, exhibited a distinct seasonal pattern plus some irregular oscillations. The seasonal component from each series was isolated and removed by the techniques of harmonic analysis. A correlation analysis, adjusting for the autocorrelation remaining in the residuals, indicated that changes in the daily air pollution level, as measured by the oxidant and carbon monoxide concentration, exerted no detectable influence upon the day-to-day mortality pattern. Carbon monoxide levels were found to range from about 7 to 22 ppm. and oxidant from 4 to 21 pphm. It is emphasized that these findings, which deal only with the acute terminal response of man to variations in the daily air pollution level, do not mitigate the importance of air pollution as a possible menace to the health and well-being of man. - APCA 3847

306. Litzner, St.: On circulation and damage to the heart due to carbon monoxide poisoning. Medizinische Klinik 32:630-631, 1936.

Author discusses the effect of CO poisoning and the general damage to the capillaries, which is responsible for the secondary sickness phenomena-damage to circulation and to the heart. Attention should be paid, as soon as possible to these conditions and the general atony of the vessels should be counteracted by medication. Until recently little attention had been paid to the change in the heart. Passing functional disturbances or organic damage may occur as consequence of damage to the vasa privata, affecting muscles and the nervous system. Sinus bradicardia, arrhytmia and ventricular extrasystology appeared in a patient after asphyxiation with CO, from which he recovered within several weeks. At the same time dilation of the left ventricle was noted. Further observations of likely disturbances are urgently needed. - From German-AGC

307. Mills, C.A., and Porter, M.M.: Tobacco smoking and automobile-driving stress in relation to deaths from cardiac and vascular causes. Amer. J. Med. Sc. 234:35-43 (July) 1957.

A direct association well beyond the realm of reasonable chance occurrence has been found to exist between cardiovascular disease death rates in white men and the amount of cigarette smoking in which they habitually indulge. Superimposed upon all categories of this cigarette smoking relationship is a further sharp death-rate rise associated with annual driving mileages above 12,000 miles, and still further superimposition in all categories is associated with residence in the solidly built-up basin areas of the city (Cincinnati).

These relationships are essentially analogous to those we found to exist for lung cancer death rates in white men, although the apparent exacerbating relationship was much greater between smoking and lung cancer deaths than between smoking and cardiovascular disease deaths. - Authors' Sum.

308. Neubuerger, K.T., and Clarke, E.R.: Subacute carbon monoxide poisoning with cerebral myelinopathy and multiple myocardial necroses. Rocky Mountain Med. J. 42:29-35 (Jan.) 1945.

A case of subacute CO poisoning in a 19-year-old girl is reported. The condition led to death after thirteen days. Autopsy revealed cerebral myelinopathy and myocardial necrosis. The pathogenesis of these lesions is discussed. The significance of a low concentration of CO together with high atmospheric temperature in the present case is emphasized. - Authors' Sum.

309. Querci, M., Margaglia, F., Orione, G., and Acquaro, G.: Hemodynamic variations in experimental acute carbon monoxide poisoning. Rassegna di Medicina Industriale e di Igiene del Lavoro 33:454-455 (May-Aug.) 1964.

The authors have observed that the inhalation of CO by laboratory animals produces an increase in the cardiac frequency with a simultaneous increase in the systolic pressure which decreases progressively when the carboxyhemoglobinemia values reach about 10%. The marked progressive increase of the pressure of the pulmonary arteries is probably due not so much to the decrease of the alveolar tension of the oxygen but to the decrease of the oxygen in the blood. - Authors' Sum.

310. Shafer, N., Smilay, M.G., and MacMillan, F.P.: Primary myocardial disease in man resulting from acute carbon monoxide poisoning. Amer. J. Med. 38:316-320 (Feb.) 1965.

The purpose of this paper is to present a case of myocardial damage resulting from acute carbon monoxide poisoning. A review of the literature reveals a paucity of such reports. The standard textbooks of medicine make little or no mention of cardiac signs and symptoms arising from carbon monoxide poisoning, but emphasize instead cerebral involvement. The case presented herein is of further interest as the patient has remained symptomatic to the present time and has shown persistent changes on the electrocardiogram; the electrocardiographic patterns reported thus far consist of transient and reversible changes. - Authors' Abst.

311. Vollmer, E.P., King, B.G., Fisher, M.B., and Birren, J.E.: The Effects of Carbon Monoxide on Three Types of Performance, at Simulated Altitudes of 10,000 and 15,500 Feet. NMRI Res. Project X-417, Report No. 7, Feb. 27, 1945, and J. Exp. Psychol. 36:244-251, 1946.

Measurements of the critical flicker frequency threshold, body sway, and the red visual field were made on subjects before, during and after low pressure chamber runs. Twenty subjects with 12 to 22 per cent blood carboxyhemoglobin (COHb) took part in runs at 15,500 feet, and six subjects with 5 to 10 per cent COHb were tested at 10,000 feet. Control runs were made at the same altitudes with the same subjects.

There was a significant impairment of performance at altitude, both under conditions of anoxia alone and anoxia after exposure to carbon monoxide (CO) as compared with performance at sea level.

There was no statistically significant difference between the mean scores of the tests during anoxia alone and during anoxia following administration of CO. Furthermore, the time-performance curves for group means during the hour at altitude are nearly coincident under the two conditions.

All the mean values for performance of each of the three tests at altitude are within one standard deviation of the sea level mean. (More than one-half of the scores for individual performance in the two series may therefore be expected to fall within the range of performance of normal subjects at sea level.)

Individual responses were variable and without correlation with the percentage of increment or of total COHb in the blood.

Three of the subjects who started the experiments showed symptoms of impending collapse at 15,500 feet without CO. One of these had successfully completed his corresponding CO run; the other two did not participate in CO runs.

Five subjects showed symptoms of impending collapse at altitude (one at 10,000, four at 15,500 feet) after they had breathed mixtures containing CO. - Authors' Sum.

Cerebral Effects

312. Bell, M.A.: Subacute Carbon Monoxide Poisoning. Arch. Environ. Health 3:108-110 (Nov.) 1961.

Attention is directed to unexpected collapse or fainting upon mild to moderate effort as a clue to cerebral hypoxia possibly due to carbon monoxide poisoning not revealed in the patient's initial history. A case considered to be illustrative is presented in this paper. -Author's Sum.

313. Chornyak, J., and Sayer, R.R.: Studies in asphyxia. I. Neuropathology resulting from comparatively rapid carbon-monoxide asphyxia. Pub. Health Rep. 46:1523-1530 (June) 1931.

The chemical and pathological reaction of dogs to asphyxia by carbon monoxide and by atmospheres which are deficient in oxygen has been studied during the past two years by the United States Bureau of Mines. These studies have been conducted for the purpose of obtaining fundamental information on the response of the organism to asphyxial environment, with the particular viewpoint of devising a procedure for treating moribund cases of carbon-monoxide poisoning. It has been repeatedly observed that many of these cases have a fatal termination, even though respiration has been induced and the carbon monoxide removed from the blood.

The neuropathology produced in dogs by fatal exposures of 20 to 30 min. to 0.6% CO in air by volume was studied. Carbon monoxide produces a diffuse degenerative change throughout the entire brain. In this type of asphyxia the most serious effect appears to be edema of the dorsal motor nucleus of the vagus and the adjacent area in the medulla oblongata. - Authors' Introduction Modified-AGC

314. Courville, C.B.: The process of demyelination in the central nervous system. IV. Demyelination as a delayed residual of carbon monoxide asphyxia. J. Nervous Mental Dis. 125:534-546, 1957.

In this study of a series dealing with the process of demyelination, the changes in the cerebral and cerebellar centrums have been noted following severe asphyxia incident to carbon monoxide. Such changes are "delayed" in the sense that a suitable time interval must elaspe after the asphyxial episode, 76 days in the case herein reported. The characteristic alterations constituting the residual lesions were 1) perivascular demyelination as the initial lesion, leading to 2) diffuse demyelination by confluence of these individual foci, 3) the tendency to spare the subcortical arcuate fibers, 4) vascular changes in the form of a decrease in number of capillaries in the degenerative foci, and a progressive collapse and disappearance of the arterioles in the affected area, 5) a decrease in the number of oligodendroglia in the degenerative areas, 6) the obvious secondary nature of loss of myelin being an effect of ischemia and 7) the occasional occurrence of islands of preservation in the periphery of the lesion.

The findings are significant in their remarkably close correlation to the changes observed in diffuse sclerosis. But in addition, there was found evidence of support for the conclusion that demyelination per se is very likely a secondary process, probably never a primary one. It is also very likely that the loss of oligodendroglia in areas of demyelination (i.e., the plaques of multiple sclerosis) is due to their sensitivity to ischemia (local anoxia) and bears no cause-effect relationship to the process of demyelination. - Author's Sum.

315. Courville, C.B.: Forensic neuropathology. XI. The asphyxiant gases. J. Forensic Sc. 9:19-46 (Jan.) 1964.

Noxious gases or vapors which produce untoward manifestations in man may be divided into the direct asphyxiants, whose toxic effects are due mainly to replacement of oxygen, and the indirect asphyxiants, whose toxic effects result from absorption of poison through the air passages. There are three types of direct asphyxiants: simple asphyxiants (smoke, fumes, and inert gases), chemical asphyxiants (carbon monoxide and cyanide gas), and central depressants (the anesthetic gases).

The primary effect of the simple asphyxiants is the exclusion of oxygen from the lungs. The chemical asphyxiants produce anoxia either by preventing the transportation of oxygen in the blood stream or by interfering with its utilization by the nerve cells of the brain. The central depressants produce anoxia by direct narcotic action on the cortex and basal ganglia, or by the precipitation of cerebral or respiratory failure and superimposition of other types of anoxia.

The indirect asphyxiants are divided into the industrial gases and the war gases. The most common industrial gases are hydrogen sulfide, sulfur dioxide, and ammonia.

In acute asphyxiation (survival up to two weeks), the brain is severely congested, with focal hemorrhages in the leptomeninges and white matter. Distention of the small blood vessels, perivascular hemorrhages and acute changes in the nerve cells occur. The parenchymatous elements and the Purkinje cells may also show acute change. Focal or laminar necrosis of the cortex and central necrosis of the basal ganglia are often associated with proliferation of the endothelium of the small blood vessels.

In the subacute stage (two to six weeks), a variety of cerebral lesions develop. Congestion may be present and focal cortical and subcortical softening may be seen. The cerebral cortex may have a diffuse granular appearance or may show a thin yellow zone of necrosis. Usually, softening of some portion of the basal ganglia will be found. Patchy, focal, laminar or subtotal necrosis occur in the cerebral cortex, with changes in the astrocytes and microglia, and proliferation of the vascular endothelium. The arterioles of the lenticular nucleus may contain rings of calcium or iron. The unmyelinated cortical nerve fibers, the myclinated sheaths of the corticofugal nerve fibers, and the white matter may show degenerative changes. The Purkinje cells may be changed and reduced in number. Deterioration of the granule cell layer may also occur.

The residuals of severe anoxia may be only minor, diffuse leptomeningeal thickening and cortical nerve cell loss, or they may be irregular cortical atrophy, cyst formation due to focal softenings, and central softening and demyelination. Microscopically, the cytological alterations observed in the subacute stage are present, as are iron deposits in the nerve cells. - Author's Sum.

316. Gilinskiy, V.A., Chapek, A.V., Kozlova, A.G., Kulikova, N.M., and A. Ya. Loshak: The effect of low concentrations of carbon monoxide on man in pressurized cabins of passenger planes. In: Parin, V.V. (editor) Aviation and Space Medicine, Moscow, 1963. NASA Technical Translation TT-F-228.

Pressure-chamber experiments were performed on 82 persons to study the effect of low concentrations of carbon monoxide. Also, 30 flights on IL-18, AN-10, and TU-104 planes were made during which 185 members of the crew and passengers were examined and 347 air samples were obtained in the cabins. The results of the investigations showed that 3 hours' exposure to carbon monoxide (starting with 0.01 mg/liter or more), both under experimental conditions (ground and pressure-chamber at 2400 m) and during actual flight had adverse effects on the functioning of several organs and systems, namely: (a) Higher nervous activity; (b) Functions of the visual and vestibular analyzers; (c) Metabolic processes; (d) Cardiovascular system; (e) Muscular strength; (f) Tissue respiration and; (g) Leukopoiesis. On the basis of the physiological-sanitary data obtained and the results of laboratory tests, it is suggested that the maximum permissible concentration of carbon monoxide in pressurized passenger airplane cabins be 0.01 mg/liter. - Authors' Abst.

317. Hill, E., and Semerak, C.B.: Changes in the brain in gas (carbon monoxid) poisoning. J. AMA 71:644-648 (Aug. 24) 1918.

Carbon monoxid poisoning produces a characteristic lesion of the brain, namely, a bilateral ischemic necrosis of the lenticular nucleus, especially the globus pallidus. This lesion results from the vascular disturbance brought about by the presence of carbon monoxid in the circulating blood which produces a thrombosis with degeneration of the vessel walls. Anatomic peculiarties in the circulation account for the localization of the lesion. The necrosis varies from slight perivascular lesions in the globus pallidus to grossly visible softening of the entire lenticular nucleus and internal capsule, depending on the amount of gas inhaled, duration of life after poisoning, and preexisting pathologic changes in the cerebral vessels.

Spontaneous hemorrhages in the leptomeninges and punctiform hemorrhages throughout the white matter of the brain are part of the profound vascular disturbances in carbon monoxid poisoning.

Nerve cells possess a high degree of tolerance to the poisonous action of carbon monoxid.

Edema and hyperemia of the brain and internal hydrocephalus are frequent appearances in carbon monoxid poisoning.

Carbon monoxid poisoning as a cause for the subsequent development of nervous and mental disease as well as for deaths which may not be explained easily receives emphasis from this study. The occupation and other conditions of living as well as careful gross and microscopic examination of the brain are of importance in demonstrating such a causal relationship. - Authors' Sum.

318. Lentz, E.C.: Human factors in "cause undetermined" accidents. Aerospace Med. 36:214-222 (March) 1965.

USAF aircraft accidents over a four-year period that remain categorized as cause undetermined indicate that the man-machine complex tends to fail during the stressful phases of flight. Loss of control and high speed impact are factors common to many of this series. Man's limitations and specifically his ability to maintain orientation - i.e., disorientation - are major problems in the operation of high performance aircraft. Aircraft performance has advanced to the place where exploration of the operational perimeters of the craft is reserved for the test pilot. Experienced combat pilots may still be novices with respect to the vagarities of the aircraft he flies. Safety of flight is enhanced by the division of duties with a qualified co-pilot.

Loss of control due to impaired consciousness attributable to carbon monoxide from refueling operations has been raised as a possibility. There are two instances in this series of loss of control associated with refueling operations. Turbine engines are efficient oxidizers of fuel. This combined with distances and dilution seriously compromises the hypothesis that the cockpit of a plane could accumulate disabling amounts of carbon monoxide from air refueling operations. - Author's Abst. Modified

319. Lewey, F.H., and Drabkin, D.L.: Experimental chronic carbon monoxide poisoning of dogs. Amer. J. Med. Sc. 208:502-511 (Oct.) 1944.

Dogs, exposed for 5½ hours per day, 6 days a week, over 11 weeks, to an atmosphere containing 0.01 vol. % CO, and reaching daily 20.1 ± 1.1% HbCO, showed a consistent disturbance of postural and position reflexes, and of gait.

Some of them showed a pathologic electrocardiogram, characteristic of anoxia, and necrosis of single heart muscle fibers.

Their central nervous systems showed, 3 months after termination of the experiment, histologic changes in the cortex and white matter of the cerebral hemispheres, in the globus pallidus and the brain stem. These alterations corresponded in type and localization to those found in acute CO poisoning, but were smaller, more scattered and less destructive. They followed in their arrangement the course of bloodvessels, the walls of which were damaged only occasionally.

One dog, in which the posterior coronary artery had been ligated 1 year prior to the exposure for a period of only 18 days to CO, showed the earliest and severest cardiac and cerebral changes of all animals observed. This result suggests that an inadequate functioning heart increases the general risk in CO poisoning, and may be responsible for a higher degree of brain damage.

Our findings indicate that chronic CO intoxication may occur in dogs at CO concentrations which have been regarded as being within the safety limits for man.

These experiments do not permit any conclusions as to the potential reactions of the human body to the same conditions. - Authors' Sum.

320. Lhermitte, J., and Ajuriaguerra, D.: Lesions of central nervous system produced by carbon monoxide poisoning. Semaine des Hôpitaux de Paris 22:1945 (Nov. 14) 1946.

According to the authors the changes in the brain in carbon monoxide poisoning differ widely, depending on the time elapsed between the exposure and necropsy. Hemorrhages, necrobiosis, necrosis and edema characterize the anatomic picture in cases in which death occurred rapidly. These changes may involve primarily the lenticular nuclei but also the subcortical white matter, the hippocampus, the substantia nigra and the cerebellum. Changes in the vascular network with infiltration of the walls by neutral lipids and by a peculiar substance containing ferric salts, calcium and lipids may be observed in cases in which the poisoning continues for a prolonged period or in which death is delayed. A diffuse demyclinization of the entire white matter of the brain similar to Schilder's diffuse cerebral sclerosis may be observed in cases in which death occurs after a long period of remission. It is suggested that in carbon monoxide poisoning a toxic factor in addition to the anoxic factor affects the neuroglia and the vascular network, with specific involvement of the basilar region and the white fibers of the centrum ovale.

321. McConnell, J.W., and Spiller, W.G.: A clinicopathologic study of carbon monoxid poisoning. J. AMA 59:2122-2126 (Dec. 14) 1912.

Authors cite actual cases of acute carbon monoxid poisoning and the sequela thereof.

Authors divide poisoning by CO into three classes: acute poisoning, chronic poisoning and the third class is designed as relapsing CO poisoning a term used to indicate the conditions of those who, having apparently recovered from the initial effect of the poison, develop after a period of fair health a grave type of symptoms leading to death.

The special clinical interest in case study described lies in the time which elapsed between the initial poisoning and the development of the grave symptoms, in the bilaterality of the motor symptoms, in the intense spasticity present and in the absence of distinct vasomotor or trophic symptoms. - AGC

322. Neubuerger, K.T., and Clarke, E.R.: Subacute carbon monoxide poisoning with cerebral myelinopathy and multiple myocardial necroses. Rocky Mountain Med. J. 42:29-35 (Jan.) 1945.

A case of subacute CO poisoning in a 19-year-old girl is reported. The condition led to death after thirteen days. Autopsy revealed cerebral myelinopathy and myocardial necrosis. The pathogenesis of these lesions is discussed. The significance of a low concentration of CO together with high atmospheric temperature in the present case is emphasized. - Authors' Sum.

323. Salen, E.B.: The period of carbon monoxide (the "generator gas epoch") in Sweden 1939-1945. Nordisk Med. 30:923-934 (April 26) 1946.

In connection with the almost total lack of mineral oils in Sweden in 1939 the country was forced to make a sudden change-over to carbon monoxide. In 1941 the number of "gengas" cars in the country amounted to 72000, in 1942 to more than 100,000. The number of persons that during work came in contact with gengas was estimated in 1942 to have amounted to between 200,000 and 250,000. As a result there were a great number of cases of acute carbon monoxide intoxication. Further, there were a number of cases of a disease designated as chronic carbon monoxide intoxication. The diagnosis in question has been based on the following criteria: 1) absence of ascertainable acute CO intoxication; 2) existing sensibility to CO; 3) characteristic picture of symptoms, and the appearance of the separate symptoms in a certain characteristic order of time; 4) the possibility to ascertain, in certain (as a rule serious) cases, a) "super-sensibility" to CO on testing, b) positive oto-neurologic test, c) the existence of ophthalmo-neurologic changes, d) pathological issue of alcohol test, e) deterioration of memory, concentration, and learning functions, ascertainable through psychiatric examination. The author is of the opinion that this proves the relatively frequent occurrence of lesional and functional brain changes in chronic carbon monoxide intoxication. - Author's Sum. Modified.

324. Schulte, J.H.: Effects of mild carbon monoxide intoxication. Arch. Environ. Health 7:524-37 (Nov.) 1963.

The effects of exposures for varying lengths of time to an atmosphere containing 100 ppm. of carbon monoxide were measured in a group of 49 healthy men between 25 and 55 years of age. This exposure produced levels of carboxyhemoglobin in the blood of the subjects ranging from 0-20%. Impairment of function due to exposure to CO occurred earliest in the higher centers of the central nervous system in that area (or areas) of the brain which controls some of the cognitive and psychomotor abilities. Impairment is detectable at levels of carboxyhemoglobin below 5%, and the degree of impairment increases with increasing concentration of the carboxyhemoglobin in the blood. The need for reducing the max. allowable concentration of CO in the working environment has been speculated upon. - APCA 5699

325. Sklenovsky, A.: Brain levels of free aminoacids in carbon monoxide anoxia in rats. Activita Nervosa Superior 6:272-275, 1964.

A significant decrease in glutamic acid (by 15%), glutamine (by 16%), serine, and glycine; and a significant increase in alanine were found after 25 minutes CO anoxia. The level of gamma-aminobutyric acid did not change. The results are related to a stimulation of glycolysis and simultaneous depression of aerobic oxidation of glucose in the Krebs cycle. The changes observed may participate in the mechanism of functional brain disorders in anoxia. - NASA 80230

326. Xintaras, C., Ulrich, C.E., Sobecki, M.F., and Terrill, R.E.: Brain potentials studied by computer analysis. Arch. Environ. Health, in press.

The operation of an on-line digital computer that summates evoked low-amplitude brain responses to flashes of light in the implanted rat is described. The application of this technique in developing a "biological model" for inducing a reversible functional blindness in rats inhaling carbon monoxide is considered. The differential rate of recovery of specific components of the evoked response to carbon monoxide and pentobarbital are more easily resolved with this method. The use of the technique of the evoked response in parallel animal and human inhalation toxicity studies involving time-limited perceptual phenomena is suggested. - Authors' Abst.

327. Bokonjić, N.: Stagnant Anoxia and Carbon Monoxide Poisoning. A Clinical and Electroencephalographic Study in Humans. Electroencephalography & Clinical Neurophysiol., 1963, Suppl. 21, 102 pp.

A detailed description and comparison of clinical and electroencephalographic symptoms in humans suffering from acute anoxia due to strangulation and carbon monoxide poisoning is provided in this publication. The important differences of these two types of anoxia are clinical and electroencephalographic syndromes which require differential prognosis. The association established between duration of unconsciousness and recovery prospects, and clarification of the influence of age and cardiovascular failure on the final outcome, are of particular prognostic value. - AGC

328. Carlo, S., and Bruno, P.: Biochemical and E.E.G. findings in some modern occupational poisonings. Riv. Sper. Freniat. 87:858-862 (June) 1963.

The literature on biochemical or E.E.G. findings of investigations of various industrial poisonings, is reviewed in this paper. Acute CO poisoning of rabbits resulted in cortical depression. Sharp reduction in the responsiveness of the electrical activity of the brain to intermittent photic stimulation was recorded immediately after the acute poisoning was induced. This condition could be reversed after a few days. Authors consider the many enzymic activities, such as dehydrogenase, flavine cyto-chrome-oxidase responsible for the changes in E.E.G. patterns. Authors draw the conclusion from the literature reviewed that only through the correlation of biochemical, histopathological and electrophysiological data, advances in industrial medicine can be made. They state that no data are, as yet, available concerning the activity of various parts of the central nervous system in industrial poisonings. - AGC

329. Gaultier, M., Fournier, Et., Gervais, P., and Bodin, F.: Pancreatic encephalopathy occuring after carbon monoxide poisoning. Presse Medicale 72:3263-3265 (Dec. 19) 1964.

In the course of an encephalopathy following carbon monoxide poisoning, the existence of a sever digestive syndrome, important body-fluid disorders, and a hyperglycemia with an important increase of amylase led to a diagnosis of acute pancreatitis. The mixture of ailments reacted favorably under the influence of treatment by anti-enzymes. This observation raises the general problem of the role which a pancreatic seizure could play in determining the secondary encephalopathic complications from carbon monoxide poisoning. - Authors' Abst.- translated CBK

330. Grudzinska, B.: Electroencephalographic patterns in cases of chronic exposure to carbon monoxide in air. Folia Medica Cracoviensia 3: 493-515, 1963.

The purpose of this study was to ascertain whether chronic exposure to CO produces pathologic changes in man and to analyse electroclinical correlations. Sixty workers from gas works and coking plants exposed to CO concentrations not exceeding 0.01% were studied. The control group consisted of 30 workers similarly employed but not exposed to CO. Only healthy individuals were included in both groups without history of cranial trauma or acute CO poisoning. Examination included determination of erythrocyte counts, Hb and COHb levels, complete history, functional tests of the vegetative nervous system. EEG's were made at rest and after activities. CO exposure was confirmed by examination of COHb. The mean level of COHb was 7.4% in the exposed group, and 3% in the control group. The COHb level exceeded 10% in 11 persons of the exposed group. A neurasthenia syndrome was diagnosed in 63% of the exposed group and in 40% of the control group. The type and intensity of complaints in each group was studied. Statistical analysis of the differences revealed significantly greater incidence of headache and general debility in the exposed group.

Among the normal tracings from the exposed group there was a significantly higher proportion of flat, low-voltage tracings with scanty alpha rhythm ($p < 0.01$).

Statistically significant electroclinical correlations were found in the group exposed to CO. All the pathologic tracings and 81% of the low-voltage tracings and those with scanty alpha rhythm were found in individuals with neurasthenic syndromes. In addition, all the tracings of the first sleep phases were also found in neurasthenic individuals.

From the findings it may be concluded that chronic exposure to low concentrations of carbon monoxide does not cause distinct changes in the nervous system, but may have a certain inhibitory effect on the bioelectric activity of the brain, manifested clinically as neurasthenia and in the EEG as scantly low-voltage alpha rhythm and tracings of the first sleep phases. However, since these changes are nonspecific, EEG examination in cases suspected of chronic CO poisoning is not decisive, although it may be auxiliary factor in making the diagnosis. - Author's Sum. Modified

331. Helmchen, H., and Künkel, H.: Findings on rythmic potential fluctuation in optically evoked responses in the human EEG. Archiv für Psychiatrie und Zeitschrift f. d. ges. Neurologic 205:397-408, 1964.

Various aspects of rhytmic potential fluctuations (rhytmic after-fluctuations) are described in this paper, developing often within an irritation response, immodiately after a secondary component. These findings indicate that the essential characteristics of these rhytmic potential fluctuations are influenced by the central nervous system. This is being demonstrated by general changes in the EEG after CO intoxication, by the anomaly of occipitals 3-4/sec-rhythmus and by paroxymol dysrhythmic and overall changes under treatment with Perazin. - Authors' Abst.-Translated--AGC

332. Lindenberg, R., Preziosi, T., Levy, D., and Christensen, M.K.: Experimental investigation of carbon monoxide toxicity. Presented at the Air Pollution Medical Research Conference, Los Angeles, Calif., Dec. 4-7, 1961.

Experiments performed by the authors indicated that the effects of CO were not completely accounted for by hypoxemia. After single exposures, dogs exhibited necrotic lesions in the white matter of the brain, probably resulting from capillary stasis produced by a high venous-arterial pressure. Electrocardiographic changes, however, appeared before electroencephalographic changes persisted for several days after exposure. When dogs were exposed for 6 weeks to either 100 ppm of CO six hours daily, 5 days a week, or to 50 ppm 24 hours daily, 7 days a week, no significant clinical effects other than a predictable degree of carboxyhemoglobinemia were observed, but at autopsy the heart and sometimes the cerebral ventricles were dilated and in some dogs the heart muscle was scarred. - A.G.C.

333. Serra, C., and Pannain, B.: Biochemical and E.E.G. findings in some modern occupational poisonings. Riv. Sper. Freniat. 87:858-862 (June) 1963.

From the numerous findings briefly reviewed the conclusion can be drawn that the most important advances in Industrial Medicine or in Legal Medicine can be achieved only through the correlation of many findings, such as the biochemical, the histopathological and the electrophysiological data.

No data are as yet available concerning, for instance, the activity of various parts of central system in different professional poisonings.

Likewise, in view of the regional differencies of enzymic activities in central nervous system, it is possible to foresee that the correlation between the EEG changes and the neurochemical findings can give a satisfactory explanation of the elective neurotropism of various industrial poisonings. - Authors' Sum.

334. Zorn, H.: On the diagnosis of chronic CO poisoning. (German) Rass. Med. Indust. 33:325-329 (May-Aug.) 1964.

The author has the opportunity of observing a group of workmen who worked in noisy premises and were exposed to low concentrations of CO over a relatively long period on account of a leak of gas which had not been noticed. Examinations and psychological tests when compared to those previously made showed an increase in the excitability and irritability to noises. The percentage of carboxyhemoglobinemia varied between 10 and 20%. The electroencephalogram revealed a picture of extremely unstable frequency. When the leak had finally been found and stopped, the tests returned to normal after eight weeks in the young subjects and after 16 in the elderly and old. These observations led the author to advise a series of examinations and tests to be given to workmen at intervals of 3-4 years, so as to follow up the action of sub-toxic concentrations of CO. - Author's Sum.

EKG Patterns

335. Belza, J.: Electrocardiographic changes following acute carbon monoxide poisoning. Inaugural-Dissertation for the Degree of Doctor of Medicine. P.G. Keller, Winterthur, Switzerland, 1955, pp. 39.

The aim of this dissertation is to present the effect of acute carbon monoxide poisoning on the heart. The damaging influence on the myocardium as reflected in the clinical picture and electrocardiogram during the past ten years at the Medical Clinic of the University of Zürich, has been studied in particular. Frequency of pathological changes in the ECG following acute CO poisoning are discussed, and an attempt has been made to estimate the relation of the age factor to the speed of improvement of electrocardiographic findings. The most recent literature related to this problem is also reviewed. - Author's Sum. Modified-AGC

336. Colvin, L.T.: Electrocardiographic changes in a case of severe carbon monoxide poisoning. Amer. Heart J. 3:484-488, 1927-1928.

The points of interest in this case seem to be:

The electrocardiographic changes due apparently in the main to asphyxia, but possibly in some degree to the action of benzol, were such as to suggest damage below the division of the His bundle instead of at the A-V node.

These changes, suggesting damage to the ventricular muscle, disappeared rapidly and completely.

The supposition that if such damage may be done to a presumably healthy heart, an already impaired myocardium might, under similar conditions, suffer irreparably. - Author's Sum.

337. Cosby, R.S., and Bergeron, M.: Electrocardiographic changes in carbon monoxide poisoning. Amer. J. Cardiol. 11:93-96 (Jan.) 1963.

In 10 patients with severe carbon monoxide toxicity, electrocardiograms were abnormal in 9. In the 3 patients reported in detail, electrocardiographic changes consisted of arrhythmias (auricular fibrillation), ischemic changes and probable subendocardial infarction. In 2 severely ill patients the electrocardiographic pattern did not return to normal for four weeks, and the clinical course was compatible with moderately severe coronary artery insufficiency and myocardial damage. Anoxia, toxic changes and true coronary ischemia secondary to shock may all play a part in carbon monoxide poisoning, depending on concentration, duration of exposure and presence or absence of shock. - Authors' Sum.

338. Ehrich, W.E., Bellet, S., and Lewey, F.H.: Cardiac changes from CO poisoning. Amer. J. Med. Sc. 208:511-523, 1944.

Discussed in this paper are acute experiments at 40% carboxyhemoglobin and in chronic experiments at 21% carboxyhemoglobin or an equivalent oxygen deficiency, electrocardiographic and morphologic changes were seen, including inverted T wave, elevated R-T segment, and degenerative changes in individual muscle fibers. When the carboxyhemoglobin exceeded 75% for an hour or more, atrioventricular heart block and myocardial hemorrhage and necrosis supervened.

339. Lindenberg, R., Preziosi, T., Levy, D., and Christensen, M.K.: Experimental investigation of carbon monoxide toxicity. Presented at the Air Pollution Medical Research Conference, Los Angeles, Calif., Dec. 4-7, 1961.

Experiments performed by the authors indicated that the effects of CO were not completely accounted for by hypoxemia. After single exposures, dogs exhibited necrotic lesions in the white matter of the brain, probably resulting from capillary stasis produced by a high venous-arterial pressure. Electrocardiographic changes, however, appeared before electroencephalographic changes persisted for several days after exposure. When dogs were exposed for 6 weeks to either 100 ppm of CO six hours daily, 5 days a week, or to 50 ppm 24 hours daily, 7 days a week, no significant clinical effects other than a predictable degree of carboxyhemoglobinemia were observed, but at autopsy the heart and sometimes the cerebral ventricles were dilated and in some dogs the heart muscle was scarred. - Sch 193, p. 121

339a. Mainardi, M.: Electrocardiographic alterations in cases of acute intoxication from carbon monoxide. Rass. Med. Ind. (Rome) 33: 420-429 (May-Aug.) 1964.

A study has been made of electrocardiographic alterations in subjects with acute carbon monoxide intoxication who were observed at the medical department of Gallarate Hospital. These alterations would appear to be due not only to the anoxemic action of CO but also to a cytotoxic one shown by increases in transaminases, in particular of lactic dehydrogenase, even in instances where the damage was transient. - LC 64-197

340. Middleton, G.D., Ashby, D.W., and Clark, F.: Delayed and long-lasting electrocardiographic changes in carbon-monoxide poisoning. Lancet 1: 12-14 (Jan. 7) 1961.

Two cases of carbon-monoxide narcosis are reported in which long-lasting changes were seen in serial electrocardiograms taken up to 3 months after exposure. An early return of the electrocardiogram to normal should not preclude continued follow-up. - Authors' Sum.

341. Stearns, W.H., Drinker, C.K., and Shaughnessy, T.J.: The electrocardiographic changes found in 22 cases of carbon monoxide (illuminating gas) poisoning. Amer. Heart J. 15:434-447, 1938.

Carbon monoxide asphyxia, even though severe enough to cause death, may produce no important electrocardiographic changes.

Changes in the T-waves and in the S-T segments occur most frequently.

Paroxysmal auricular fibrillation may occur, as a rule in patients within the age group in which any physiologic insult or trauma may cause this condition.

One case of transitory intraventricular block is present in the series.

No cases of auriculoventricular block definitely attributable to carbon monoxide poisoning were found, although one case is reported in which a marked disturbance of auricular rhythm with partial auriculoventricular block was apparently aggravated by the asphyxia. - Authors' Sum.

342. Takahashi, K.: Cardiac disturbances due to CO poisoning in experimental animals. I. Electrocardiographic changes due to CO poisoning and those under the influence of fluid infusion. Tohoku J. Expt. Med. (Sendai) 74:211-223 (July 25) 1961.

Rabbits under urethane anesthesia, were allowed to inhale through a cannula into the trachea for fixed periods, a mixture of room air and 0.3 or 1% CO gas. Electrocardiograms were made immediately, then after 24, 48, or 96 hrs. a fluid infusion was given and this was followed by a 2nd EKG. Microscopic examinations, following autopsy, were made of the hearts of the animals. The carboxyhemoglobin (COHb) levels in the blood had reached 33.9-42.5% on inhalation of a 0.3% CO for 30 min., and 36.6-43.9% for 60 min. The COHb level never reached the saturation value. The drop in COHb levels for the 1st 30 min. after cessation of gas inhalation was more prompt in animals poisoned for the shorter period of time. Changes in EKG were observed in 12 of the 20 animals during gas inhalation. The changes were elevation or depression of the S-T segment or a flat T wave. There was no intimate correlation between the degree of EKG changes and the COHb levels. The author infers that it may require a definite time duration over which a high concentration of COHb level is maintained, to produce the changes in EKG. Microscopic changes resemble those reported by other authors. Changes were also observed in animals which do not show changes in EKG. The changes occurring during inhalation disappeared quite soon and returned to normal after 24 hours. Infusion with Ringer-Locke solution, with 12% bovine hemoglobin added, brought about the following disorders of the EKG: extra systoles, remarkable displacement of the S-T segment, or A-V block. It is conceivable that latent changes induced by gas inhalation, even though the EKG had returned to normal, had brought about a weakening of the heart which made it unable to bear the burden of infusion. Thus the cardiac damages from the CO inhalation became evident. - APCA 4465.

343. Takahashi, K.: II. Changes of the heart excitability, due to acute CO poisoning. Tohoku J. Expt. Med. (Sendai) 74:224-233 (July 25) 1961.

Changes of the heart excitability were observed on the electrocardiogram of dogs poisoned acutely by inhalation of CO gas. Due to inhalation of 0.05-1% CO gas for 60 min., a remarkable prolongation of refractory periods was observed in all animals and the elevation of resting threshold was seen in a few animals. The lowering of heart excitability was shown not only during gas inhalation but after its cessation. Then the strength interval curve shifted to the right. Due to inhalation of 2.5% CO gas for 15 min., the heart excitability was decreased slightly during inhalation but recovered quickly by inhalation of pure oxygen. Then the absolute refractory period was reduced. It required a definite time duration for which the carboxyhemoglobin (COHb) level was maintained at a certain high level, to produce the lowering of heart excitability. Lowering of the excitability continued and became severe after cessation of gas inhalation. The disturbances of heart muscles due to CO poisoning may be attributed to disturbances of myoglobin and/or cytochrome C. The reduction of the absolute refractory period was observed by the inhalation of 2.5% CO gas for 15 min. and this may be attributed to the compensatory function in the early stage of hypoxemia. - APCA 4465.

Lung Diffusion

344. Apthorp, G.H., and Marshall, R.: Pulmonary diffusing capacity: A comparison of breath-holding and steady state methods using carbon monoxide. J. Clin. Invest. 40:1775-1784, 1961.

In 16 normal subjects and 125 patients with cardiac or respiratory disease, measurements of the diffusing capacity of the lungs for carbon monoxide (D_L) were made by both the single breath and the steady state methods with end-tidal samples as a measure of alveolar CO.

In 16 normal subjects at rest the steady state D_L was about 75 per cent of the single breath D_L. The steady state D_L increased with increasing tidal volume so that at maximal tidal volume the steady state D_L was approximately the same as the single breath D_L. The increase of D_L on exercise was greater than could be accounted for by the increased ventilation on exercise. An increase of respiratory rate without an increase in tidal volume did not increase D_L.

The patients with cardiac or respiratory disease were considered in three groups. Group 1 (74 patients with normal pulmonary gas mixing): the steady state D_L was 74 per cent of the single breath D_L at rest. Group 2 (26 patients with impaired pulmonary gas mixing but no clinical evidence of emphysema): the steady state D_L was 66 per cent of the single breath figure. The difference between groups 1 and 2 may be due, in part, to the errors in end-tidal sampling in patients with uneven pulmonary ventilation. Group 3 (25 patients with emphysema): there was no relationship between the single breath and steady state D_L. The reasons for this are discussed. - Authors' Sum.

345. Bates, D.V.: The uptake of carbon monoxide in health and in emphysema. Clin. Sc. 11:21-32, 1952.

A simple method is described for the estimation of the rate of uptake of carbon monoxide gas.

Variations in the uptake of carbon monoxide in normal subjects with differing respiratory rates and tidal volumes are described; and it has been shown that hyperventilation increases the volume of gas absorbed but lowers the percentage of the gas removed from the inspired air. These effects are modified if the hyperventilation is accompanied by exercise.

The rate of uptake of carbon monoxide has been measured in 43 cases of emphysema, and is shown to be considerably reduced in comparison with normal subjects. It is considered that this indicates that much of the inspired air is not coming into contact with pulmonary blood. - Author's Sum.

345a. Cotes, J.E.: An inter-laboratory study of the estimation of carbon monoxide. Ann. Occupat. Hyg. (London) 5:217-219 (Oct.-Dec.) 1962.

The author has been concerned with standardization of the measurement of pulmonary diffusing capacity of carbon monoxide by a single breath. From the instrumental point of view this requires the analysis of 2 gas mixtures, each containing helium and carbon monoxide. The accuracy of the resulting diffusing capacity depends on the accuracy of analysis of ratios of helium and CO concentrations in the 2 cylinders. Three test gas mixtures of known composition were decanted into smaller cylinders and then distributed in pairs to 21 laboratories where measurements of pulmonary diffusing capacity were being carried out. Complete results were received on 3 such pairs from 11 laboratories; these results were used to provide an estimate of the reproducibility and absolute accuracy of the measurement of carbon monoxide. For comparison, corresponding figures for helium were used for which the concentrations were higher. Helium is, in many ways, easier to analyze. Most of the laboratories from which results were obtained were staffed on a part-time basis under the supervision of a physician interested in the assessment of pulmonary function and not by physicists or chemists who might have been expected to have a more critical approach to the analysis. The range of results for each master cylinder has been described as a percentage of the mean concentration. For CO the range is 8.6-12.6%; the corresponding range for helium is 3.5-4.0%. Thus the scatter for CO is nearly 3 times that for helium. The results of the trial demonstrated that among physiological laboratories analyzing helium and CO, the reproducibility of individual estimates is relatively good. However, whereas there is little variation between laboratories in the analysis of helium concentrations and concentration ratios, there is considerable variation for CO and a tendency for laboratories to report consistently high or low ratios on successive occasions. These differences are reflected in the diffusing capacities which can be calculated from the data. - APCA 5351.

346. Dollery, C.T., Dyson, N.A., and Sinclair, J.D.: Regional variations in uptake of radioactive CO in the normal lung. J. Appl. Physiol. 15:411-417 (May) 1960.

Carbon monoxide labelled with O^{15} was produced by passing O^{15}, made in the Medical Research Council's cyclotron, over charcoal at 1000°C. After a single breath of the radioactive gas (900 ml.; 0.6% CO with activity of about 5 mc./l.) the rate of fall of activity during apnea was measured by external counting in different regions of the lungs of normal subjects in the sitting position. The carbon monoxide "clearance rate" calculated from these data is proportional to the diffusion/unit volume in the zone under study. There was a gradient of diffusion/unit volume; the highest value being found in the basal regions of the lung and much lower values toward the apex. On exercise the clearance rate in the upper zone increased to a value similar to that in the lower zone at rest; the clearance in the lower zone was unchanged. Measurements of the O^{15} clearance rate showed a similar gradient but on exercise both upper and lower zone values increased so that the gradient was maintained. The results are interpreted as showing that in the resting state all the basal capillaries are open but that the proportion of patent capillaries diminishes toward the apex. On exercise there is an increase in flow at both apex and base and in consequence the remaining apical capillaries open. - APCA 4258

347. Filley, G.F., MacIntosh, D.J., and Wright, G.W.: Carbon monoxide uptake and pulmonary diffusing capacity in normal subjects at rest and during exercise. J. Clin. Invest. 33:530-539 (April) 1954.

The CO uptake has been measured in 11 normal subjects breathing 0.1 per cent CO in air under resting conditions and during increasingly strenuous stints of exercise. The fraction of CO removed from respired gas decreased progressively with increasing exercise. A method for calculating alveolar CO tension has been developed. The ratio of the CO uptake to this alveolar tension has been designated as D_{co}. The mean D_{co} at rest was 16.9 in seven subjects. During moderate exercise the mean D_{co} was 36.3 in 11 subjects.

The fraction of CO removed from respired gas at a given ventilation rate varied as much as 25 per cent among normal subjects during exercise. D_{co} is considered to be important in accounting for this variation.

D_{co} showed no tendency to increase during increasingly strenuous exercise. When D_{co} is determined during exercise requiring an O_2 uptake of at least four times the resting value, it is considered to represent the maximum diffusing capacity of the lungs. D_{co} is probably a measure of the number and size of the pulmonary capillaries available for pulmonary gas exchange and the permeability of the alveolar membrane. - Authors' Sum.

348. Forster, R.E., Fowler, W.S., and Bates, D.V.: Considerations on the uptake of carbon monoxide by the lungs. J. Clin. Invest. 33: 1128-1134 (Aug.) 1954.

Preliminary investigations on the Krogh CO method of measuring the diffusing capacity of the lung revealed the necessity for re-examining the theory of CO uptake from the lungs. Equations have been derived which describe mixed expired alveolar CO concentration, during breathholding following a single inspiration of a gas containing CO and during "steady state" breathing of a mixture containing CO, when the alveoli have different ventilation rates, alveolar gas volumes, and diffusing capacities. The effect of significant amounts of COHb in the mixed venous blood is discussed. Two equations are also derived describing the expired alveolar CO concentration during the breathing of a mixture containing CO. The first deals with the initial "washout" of the lung gases, and the attainment of the gas "steady state." The second deals with the much slower build-up of COHb in the mixed venous blood. - Authors' Sum.

349. Forster, R.E., Fowler, W.S., Bates, D.V., and Van Lingen, B.: The absorption of carbon monoxide by the lungs during breathholding. J. Clin. Invest. 33:1135-1145 (Aug.) 1954.

The disappearance of CO from the alveolar gas of the lung during breathholding has been investigated in seven normal subjects.

The alveolar CO concentration did not fall exponentially with time as had been assumed by previous workers.

The most likely single explanation of this phenomenon is that the diffusing capacity per unit gas volume varies throughout the lung.

This finding is relevant to the consideration of the validity of present methods of measuring the diffusing capacity of the lungs. - Authors' Sum.

350. Forster, R.E., Cohn, J.E., Briscoe, W.A., Blakemore, W.S., and Riley, R.L.: A modification of the Krogh carbon monoxide breath holding technique for estimating the diffusing capacity of the lung; a comparison with three other methods. J. Clin. Invest. 34:1417-1426 (Sept.) 1955.

Measurements of D_{CO} were made at rest on seven subjects by a modification of krogh's breath holding technique. These findings were compared to simultaneous steady state measurements of D_{O2} by the Lilienthal-Riley technique, of D_{CO} by the Filley technique and of fractional CO uptake as described by Bates. The latter methods were applied during exercise in five of the seven subjects. All but one of the subjects were hospital patients and together they provided a wide range of values for pulmonary diffusing capacity.

It is concluded for the present that the methods for the estimation of steady state D_{O2} and D_{CO} provide similar values when allowance is made for the differences in physical characteristics between the two gases. Estimates obtained by the CO breath holding technique at rest show directional changes which are comparable to those obtained by the other methods during exercise, although the absolute values are lower. The fractional CO uptake, when uncorrected for changes in ventilation rate, is less reliable.

The optimum conditions for each method vary, and further studies of the advantages and limitations of each are required. - Authors' Sum.

351. Forster, R.E., Roughton, F.J.W., Cander, L., Briscoe, W.A., and Kreuzer, F.: Apparent pulmonary diffusing capacity for CO at varying alveolar O_2 tensions. J. Appl. Physiol. 11:277-289, 1957.

The apparent pulmonary diffusing capacity for CO (D_L) has been measured at alveolar O_2 tensions from 40 to more than 600 mm Hg. Two methods were used: a) in six healthy subjects a steady state method in which the end-expiratory tension of a continuous record of respired CO concentration was considered "alveolar" and b) in seven healthy subjects a breath holding technique. D_L, measured by either method decreased with increasing alveolar O_2 tension in all subjects, varying as much as fivefold over the entire range. All estimates of D_L were corrected for the presence of COHb in the mixed venous blood. D_L (steady state; breathing air) was on the average 0.85 of D_L (breath holding; breathing air). - Authors' Abst.

351a. Gaensler, E.A., and Wright, G.W.: Evaluation of respiratory impairment. Arch. Environ. Health 12:146-189 (Feb.) 1966.

The production of data relating to the evaluation of impairment, by methods available in the physician's office and in most urban centers, together with some aspects of the meaning of such data and the manner in which used to meet common medical problems are discussed. The importance of utilizing convential methods for evaluating respiratory impairment, such as clinical history, physical examination, and roentgenography has been established; as well as the value of objective procedures including laboratory methods. Each of the methods provides certain essential information not always obtained by the others. Each has its limitations and only by combining them can the full potential for evaluating impairment be attained. - AGC

352. Hamilton, L.H., and Smith, J.R.: A slide rule for calculating single-breath diffusing capacity for carbon monoxide. Amer. Rev. Resp. Dis. 91:112-116 (Jan.) 1965.

A circular slide rule has been constructed that permits a simple calculation of Dco performed by the breath-holding technique. It can be used when the gas analyses are performed by conventional methods or with a gas chromatograph. Use of the Dco slide rule provides an accuracy well within clinical requirements and permits the entire calculation to be completed in one to two minutes. - Authors' Sum.

353. Hanson, J.S., and Tabakin, B.S.: Steady state carbon monoxide diffusing capacity in normal females. J. Appl. Physiol. 16:839-841 (Sept.) 1961.

The diffusing capacity of the lung for carbon monoxide was determined in 100 normal females age 20-60 years during steady state treadmill exercise. Values obtained were compared with a corresponding study in males, and it was established that when body surface area is taken into account there is no significant sex difference in Dl_{co}. No significant decrease in diffusing capacity was seen with advancing age. Normal mean values and limits of normal for the various age groups are given. - Authors' Abst.

354. Hatch, T.F.: Carbon monoxide uptake in relation to pulmonary performance. A.M.A. Arch. Indust. Hyg. & Occupat. Med. 6:1-8 (July) 1952.

In man the rate of carbon monoxide uptake in relation to pulmonary performance follows the simple exponential equation for respiratory exchange of inert gases.

The rate of uptake varies directly with atmospheric concentration because the physiological "solubility" of CO in blood increases with decreasing atmospheric concentration of the gas.

The rate of uptake is independent of the pulmonary circulation rate. At rest, it is primarily dependent upon lung ventilation. Under hard exercise, the diffusion area of the lungs does not increase in proportion to the rise in ventilation rate. Consequently, the rate of CO uptake is about equally dependent upon ventilation rate and diffusion capacity. - Author's Conclusion

355. Jay, B.E., and Wilson, R.H.: Adaptation of the gas adsorption chromatographic technique for use in respiratory physiology. J. Appl. Physiol. 15:298-302, 1960.

In this paper a technique using the gas chromatograph as an analytical tool for measuring pulmonary functions is presented. The technique is vapor phase chromatography. By this method the sample gas mixture is introduced into the apparatus into a continuously flowing stream of carrier gas (which may be argon, neon, helium, hydrogen, or nitrogen), which moves the individual components through a column of selected material at different velocities according to its adsorption isotherm.

The employment of a mixture of two or more inert gases and chemically active gases for measuring the several parameters of pulmonary function simultaneously has created analytical problems. The mass spectrometer and infrared analyzer have been used by Forster et al., Riley et al. and others as a technique for obtaining the percentage composition of different mixtures of nitrogen, oxygen, carbon dioxide, helium, nitrous oxide and carbon monoxide in the study of respiratory physiology. If additional components are introduced into a gas mixture, such as nitrous oxide or acetylene, to measure pulmonary blood flow and cardiac output, the analytical problems are magnified. This is especially true when the pulmonary diffusing capacity is estimated simultaneously with pulmonary capillary flow and volume.

Ideally, for the studies of pulmonary functional residual capacity, diffusing capacity, and capillary blood flow and volume, a simple method is sought for measuring the percentage composition of a mixture of gases containing any qualitative or quantitative combination of nitrogen, oxygen, carbon dioxide, etc. Rapid dynamic simultaneous measurements of events in all phases of the respiratory cycle are desired for the best physiologic measurements. Since such apparatus is not available, the next best technique would be one that would allow batch analysis of small samples of complex mixtures of experimental gases.

Recent work in the field of chromatography has shown that chromatography can be refined into a powerful analytical tool. - Authors' Introduction

356. Johnson, R.L., Jr., Spicer, W.S., Bishop, J.M., and Forster, R.E.: Pulmonary capillary blood volume, flow and diffusing capacity during exercise. J. Appl. Physiol. 15:893-902, 1960.

Pulmonary capillary blood flow ($\dot{Q}c$) and apparent CO diffusing capacity (D_L) were calculated from the rates of disappearance of small alveolar concentrations of inspired acetylene and carbon monoxide during breath holding. Such measurements were performed simultaneously in four normal subjects at rest, during exercise and while performing Valsals or Mueller maneuvers; they were also made at more than one alveolar oxygen tension so that true membrane diffusing capacity (D_M) and pulmonary capillary blood volume (Vc) could be calculated by the method of Roughton and Forster. D_L, D_M and Vc were closely correlated with $\dot{Q}c$ ($r = 0.92$, 0.71 and 0.92, respectively), indicating that both volume and effective surface of the pulmonary capillary bed changed along wide corresponding directional changes in blood flow. During transients after starting or after stopping exercise, changes in D_L lagged slightly behind the associated changes in $\dot{Q}c$; both parameters tended to reach steady values, however, after above 1 minute of steady exercise. The average time spent by red cells in the pulmonary capillaries at rest was estimated to 0.79 second, falling to about 0.5 second at levels of exercise at which volume flow through the capillary bed was approximately tripled. - Authors' Abst.

357. Johnson, R.L., Jr., Taylor, H.F., and Lawson, W.H., Jr.: Maximal diffusing capacity of the lung for carbon monoxide. J Clinical Invest. 44:349-355, 1965.

The purpose of this investigation was to determine how much the apparent CO diffusing capacity ($D_{L_{CO}}$) increases from rest to peak exercise and whether it reaches a plateau with increasing work load. Pulmonary capillary blood flow and apparent CO diffusing capacity were measured by a breath-holding technique both at rest and during exercise and repeated at two different alveolar oxygen tensions so that the true membrane diffusing capacity ($D_{M_{CO}}$) and pulmonary capillary blood volume (Vc) could be determined by the Roughton-Forster method.

$D_{L_{CO}}$ kept rising as work load was increased until the pulmonary blood flow and oxygen consumption stopped going up. $D_{L_{CO}}$ increased principally because of a twofold increase in Vc during exercise. $D_{M_{CO}}$ increased only about 20% above the resting value.

In the three patients with mitral stenosis pushed up to their peak work loads, Vc rose to the same level as in normal subjects during exercise but did not exceed the normal upper limit. This suggests that maximal distensibility of the capillary bed in normal subjects is reached or closely approached at peak work loads. The maximal pulmonary capillary blood volume in the normal subjects as well as in the patients with mitral stenosis agrees closely with the anatomical estimates made by Weibel of the maximal capacity of the pulmonary capillary bed. - Authors' Sum.

358. Johnson, R.L.,Jr., Taylor, H.F., and De Graff, A.C.,Jr.: Functional significance of a low pulmonary diffusing capacity for carbon monoxide. J. Clinical Invest. 44:789-800, 1965.

Our purpose was to determine whether measurements of carbon monoxide diffusing capacity can be used in accord with presently accepted theory to predict the limits that a low diffusing capacity can be used in accord with presently accepted theory to predict the limits that a low diffusing capacity imposes on oxygen consumption. In six patients suspected of having alveolar capillary block pulmonary capillary blood flow, capillary blood volume (Vc), and membrane diffusing capacity for CO ($D_{M_{CO}}$) were measured at full inspiration both at rest and exercise. From these measurements we predicted how oxygen saturation of arterial blood would fall as oxygen consumption increases at a given alveolar oxygen tension. To make these predictions $D_{M_{CO}}$ and Vc were translated into terms of oxygen transport using in vitro measurements of Staub, Bishop, and Forster to estimate kinetics of oxygen uptake by capillary red cells; we assumed that $D_{M_{O_2}}$ equals 1.23 $D_{M_{CO}}$ and that lung volume, ventilation, and blood flow were uniformly distributed with respect to diffusing surface. Then the same patients were exercised on a treadmill up to the heaviest load tolerated, and the relationship between oxygen consumption and oxygen saturation of arterial blood was measured. At heavy exercise oxygen consumption approached the upper limits predicted from $D_{M_{CO}}$ and Vc even though arterial oxygen saturation began to fall at a lower oxygen consumption than predicted. Reasons for the latter discrepancy are discussed. The experimental data as well as theory indicate that maximal oxygen intake at sea level should not be limited significantly by diffusion until membrane diffusing capacity is less than 50% of predicted normal. Theory also indicates that above 10,000 feet diffusing capacity should become important as a limit to oxygen consumption even in normal subjects. - Authors' Sum. Modified

359. Jones, R.S., and Meade, F.: Pulmonary diffusing capacity an improved single-breath method. Lancet 1:94-95 (Jan. 9) 1960.

Improved procedures for the single-breath method of estimating pulmonary diffusing capacity are described.

These eliminate the anomalous variations of D_L with breath-holding time, observed using Forster's method. These arise from neglect of the effects of alveolar-volume changes during the experiment and from the use of an inappropriate breath-holding time.

At 10 seconds breath-holding time the alternative methods give a D_L which is about 20% lower than that given by Forster's method with a normal subject.

In any of its forms, the single-breath method of estimating pulmonary diffusing capacity is theoretically justified only in respect of ideally normal subjects. As this qualification applies equally to the suggested improvements, there still remains the problem of interpreting such data in the presence of inequality of ventilation, perfusion, and membrane property. - Authors' Sum.

360. Jouasset-Strieder, D., Cahill, J.M., Byrne, J.J, and Gaensler, E.A.: Pulmonary diffusing capacity and capillary blood volume in normal and anemic dogs. J. Appl. Physiol. 20:113-116 (Jan.) 1965.

The CO diffusing capacity (DL) was measured by the single-breath method in eight anesthetized dogs. Pulmonary capillary blood volume (Vc) and membrane diffusing capacity (DM) were determined in six animals by the method of Roughton and Forster. The studies were repeated after anemia had been induced by replacing whole blood with plasma. Large dogs were selected with a mean body weight of 29 kg and a mean alveolar volume of 2020 ml (STPD) during tests. The mean arterial blood Hb decreased from 14.3 to 6.6 g/100 ml, the mean DL from 27 to 12 ml/min mm Hg, and the mean DM from 100 to 47 ml/min mm Hg. The Vc averaged 67 ml in the control state and was not significantly changed during anemia. Reductions in DL and DM during anemia were proportional to the fall in blood Hb. Both DL and DM in all dogs, normal and anemic, were proportional to the volume of red blood cells in the lung capillaries (VRBC). These results suggest that VRBC might be an estimate of the useful area of the alveolar-capillary membrane while DM/VRBC should vary with changes in its thickness. The latter was not altered by anemia. - NASA 90313

361. Kilburn, K.H., Miller, H.A., Burton, J.E., and Rhodes, R.: Effects of altering ventilation on steady-state diffusing capacity for carbon monoxide. J. Appl. Physiol. 18:89-96, 1963.

Alterations in the steady-state diffusing capacity for carbon monoxide (Dco) by the method of Filley, MacIntosh, and Wright, produced by sequential changes in the pattern of breathing were studied in anesthetized, paralyzed, artificially ventilated dogs. The Dco of paralyzed, artificially ventilated control dogs did not differ significantly during 3 hours from values found in conscious and anesthetized controls. A fivefold increase in tidal volume without changing frequency of breathing raised alveolar ventilation and CO uptake 500% and Dco 186%. A high correlation between tidal volume and Dco was noted during reciprocal alterations of tidal volume and rate which maintained minute volume. The Dco appeared to fall when alveolar ventilation was tripled by increments of rate with a fixed-tidal volume, despite a 63% increase in CO uptake. Doubling end-expiratory lung volume by positive pressure breathing without altering tidal volume or rate did not affect Dco. The addition of 100 ml of external dead space with rate and tidal volume constant decreased Dco to 42% of control level, however, stepwise reduction of dead space from 100 ml to 0 in two dogs failed to change Dco. Added dead space equal to 1/2 tidal volume (170 ml) reduced Dco to 25% of control in two dogs with a return to control with removal of dead space. Thus, in paralyzed artificially ventilated dogs, tidal volume appears to be the principal ventilatory determinant of steady-state Dco. Dco is minimally affected by increases in alveolar ventilation with a constant tidal volume effected by increasing the frequency of breathing. Prolonged ventilation, at fixed rate and volume, and increased dead space either did not effect, or they reduced Dco, perhaps by rendering less uniform the distribution of gas, and blood in the lungs. Although lung volume was doubled by positive-pressure breathing, pulmonary capillary blood volume was probably reduced to produce opposing effects on diffusing capacity and no net change. - Authors' Abst.

362. Kreukniet, J., and Visser, B.F.: CO-diffusing capacity, fractional CO-uptake and unequal ventilation. Acta Physiol. Pharmacol Neerlandica 11:386-404, 1962.

Determination of the CO-diffusing capacity was carried out by the steady state technique of Filley, et al. (see no.). Lung function data of 74 patients are presented. Authors conclude from this data that the fractional CO-uptake alone is an insufficient indication to demonstrate an impairment of pulmonary diffusion, particularly in patients with a non-uniform distribution of V_A/Q_c. Of the 74 patients examined, 38 had a low fractional CO-uptake. 17 of these patients probably had no impairment of pulmonary diffusion. The procedure discussed in this paper affords a more plausible explanation of the fact that patients with non-uniform distribution of V_A/Q_c sometimes show very high or even negative D values. - AGC

363. Krogh, A., and Krogh, M.: On the rate of diffusion of carbonic oxide into the lungs of man. Skand. Arch. Physiol. 23:236-247, 1910.

According to the experiments described the value for the diffusion of carbonic oxide per mm and minute through the lungs of the subject examined may be taken as about 20^{ccm} during rest and a little above 30, when the breathing is forced, as it will be during heavy muscular work. In the latest paper by Bohr the value found during rest is 13.4^{ccm3} and immediately after very fatiguing work 28.4^{ccm}. On account of a systematic error in the determination of the alveolar tension these figures are somewhat too low. The correction which must be applied to the last of them is very nearly 10% of the value, raising it to about 31^{ccm}, or the same figure as we found. We do not think that much stress should be laid upon this coincidence. There is in our opinion every reason to believe, that the efficiency of the lungs will prove to be about as variable individually as any other function of the body. Not only have great differences been recorded in the mean and vital capacities of the lungs, but also the alveolar epithelium may possibly vary in thickness. - Authors' Sum.

364. Krogh, M.: The diffusion of gases through the lungs of man. J. Physiol. 49:271, 1915.

A new technique for the measurement of the pulmonary diffusing capacity in man is reported in this paper. In this method a maximal inspiration of gas mixture containing CO was made from residual volume and following immediately by an expiration of at least one liter of gas. At the remaining volume the breath was held for 6 to 10 seconds, and a maximal respiration was made. The final volumes of the two expirations were considered to be alveolar gas and were analyzed for CO concentrations. Author assumed that the CO concentration decayed exponentially. The equation describing this decay is given. - AGC

364a. Lewis, B.M., Lin, Tai-Hon, Noe, F.E., and Hayford-Welsing, E.J.: The measurement of pulmonary diffusing capacity for carbon monoxide by a rebreathing method. J. Clin. Invest. 38:2073-2086, 1959.

This paper describes a rebreathing method for the measurement of pulmonary diffusing capacity for carbon monoxide ($D_{L_{CO}}$) using stable CO and continuous analysis.

The fall of CO concentration in the rebreathing bag was apparently exponential for at least 15 seconds in 571 of 578 studies. In 80.4 per cent of these studies, this exponential decrease began in the first 10 seconds of rebreathing.

In four normal subjects calculated $D_{L_{CO}}$ was independent of increases in apparatus dead space. This would be true if the rate of rebreathing were infinitely fast.

In patients with emphysema calculated $D_{L_{CO}}$ decreases as apparatus dead space is increased. This would occur if the rebreathing system were ventilated breath by breath at a finite rate.

In four normal subjects the rebreathing $D_{L_{CO}}$ decreased sharply when the total volume of the lung-bag system was decreased from near total lung capacity to approximately functional residual capacity.

In 47 normal subjects the rebreathing $D_{L_{CO}}$ was significantly correlated with height, weight, body surface area and vital capacity.

There is a high correlation between rebreathing and single breath measurements of $D_{L_{CO}}$ in normal subjects and patients without airway obstruction. There is a less striking correlation between these two methods in patients with emphysema.

The residual volume determined by the rebreathing method is significantly correlated with that measured by the closed circuit helium method in both normal subjects and patients.

An empiric argument is presented for the approximate validity of the rebreathing method in patients with uneven ventilation and slow mixing in whom the rate of rebreathing is finite.

The rebreathing method is rapid, simple and gives a simultaneous measurement of $D_{L_{CO}}$ and residual volume.

The rebreathing $D_{L_{CO}}$ was definitely decreased (two-thirds or less the predicted value) in only five of 19 patients with emphysema. - Authors' Sum.

365. Linderholm, H.: On the significance of CO tension in pulmonary capillary blood for determination of pulmonary diffusing capacity with the steady state CO method. Acta Med. Scandinav. CLVI:413-427, 1957.

In a determination of the pulmonary diffusing capacity for CO, D_{CO} with the steady state method, the partial pressure of CO in the blood cannot be disregarded. If this is not taken into account about 10-20 per cent too small values of D_{CO} may be obtained. Correction for the back pressure of CO from the blood is essential when D_{CO} is large and when the CO content of the blood is high. This is more important when the determination is made at rest than during exercise.

Various methods for an estimation of the mean partial pressure of CO in the blood of the pulmonary capillaries are compared. Estimation based on blood analyses, or on the rebreathing technique, is to be preferred.

When correction for the mean partial pressure of CO in the blood of the pulmonary capillaries is made, D_{CO} seems to be independent of the CO content of the blood. If the correction is omitted, D_{CO} will decrease with increasing CO content of the blood. - Author's Sum.

366. Marks, A., Cugell, D.W., Cadigan, J.B., and Gaensler, E.A.: Clinical determination of the diffusion capacity of the lungs. Comparison of methods in normal subjects and patients with "alveolar-capillary block" syndrome. Amer. J. Med. 22:51-73 (Jan.) 1957.

This clinical study was undertaken to compare the diffusion capacity of the lungs in man at rest measured by three different methods utilizing carbon monoxide (D_{CO}) and by direct calculation from two-level alveolar-arterial oxygen "gradients" (D_{O_2}); to establish normal values for the D_{CO} methods; and to assess their clinical diagnostic value in patients with diffusion impairment. - Authors' Sum. Modified

367. Marshall, R.: A comparison of methods of measuring the diffusing capacity of the lungs for carbon monoxide; investigation by fractional analysis of the alveolar air. J. Clin. Invest. 37:394-408, 1958.

The diffusing capacity of the lungs for CO (D_L) has been measured in 5 normal subjects and in 11 patients with emphysema by the single breath method and by the steady state method, using end tidal samples as a measure of the mean alveolar CO tension. In five of the patients with emphysema, D_L was also calculated by a modification of Filley's method.

Fractional samples were taken from a full expiration after breath holding and D_L was claculated for each sample by the single breath method. In normal subjects and in patients with emphysema, D_L was uniform throughout the expired air. Fractional analysis of the expired air of normal subjects in the steady state breathing CO showed that the concentration of CO in the lungs was uniform. In these subjects end tidal samples approximated the mean alveolar concentration of CO and could be used in the calculation of the steady state D_L. Measurement of D_L by the single breath and steady state methods gave the same results in normal subjects when allowance was made for the different lung volumes at which the measurements were made.

Patients with emphysema did not have uniform concentrations of CO throughout the lung in the steady state; end tidal samples bore no relationship to the mean alveolar CO and could not be used for calculation of D_L.

A bloodless modification of Filley's method of calculation of the steady state D_L is described. This method gave results which were close to those of the single breath D_L measured in the same subjects.

The clinical value of the single breath and steady state methods for measurement of D_L is discussed. - Author's Sum.

368. Ogilvie, C.M., Forster, R.E., Blakemore, W.S., and Morton, J.W.: A standardized breath holding technique for the clinical measurement of the diffusing capacity of the lung for carbon monoxide. J. Clin. Invest. 36(Part I):1-17 (Jan.) 1957.

A modification of the Krogh breath holding technique for the clinical measurement of apparent pulmonary diffusing capacity (D_L) is described. Reproducibility was investigated in 28 normal subjects; the coefficient of variation for a single measurement on a single subject was 8.5 per cent. D_L increased with increasing body surface area, height and weight. It also increased with exercise, returning to control values within several minutes of the cessation of exercise. D_L rose with increasing degrees of exercise, but did not reach a maximal plateau in the subjects studied. D_L varied slightly with posture, being greatest when the subject was supine, less when sitting and least when standing. The importance of these and other factors in obtaining a standardized estimate of D_L is discussed.

Measurements of D_L were made in 28 patients with various pulmonary diseases. In four patients and one normal subject, D_L was measured separately in the two lungs. There were no difficulties in performing the test, and the values of D_L obtained were consonant with the clinico-pathological diagnosis. - Authors' Sum.

369. Rankin, J., McNeill, R.S., and Forster, R.E.: Influence of hypercapnia on pulmonary diffusing capacity for CO in man. Physiologist 1:68-69, 1957.

Since the pulmonary diffusing capacity for CO (D_L) theoretically varies with changes in the size of the pulmonary capillary bed, it appeared to us to be a good tool for the investigation of the effects of CO_2 on the pulmonary capillaries. Therefore we have measured D_L during hypercapnia in 9 resting normal subjects by the CO - helium breath-holding technique. a) When 10% CO_2 was simply added to the inspired gas mixture used in the measurement of D_L, D_L was increased an average of 5% and 12% after 10 and 50 seconds of breath holding respectively. Pulmonary capillary blood volume (V_c), calculated by the method of Roughton and Forster was measured in 2 subjects and was increased approximately 11%. b) After the subject breathed a gas mixture containing 7.5% CO_2 for 10 minutes, D_L was increased an average of 24% in all subjects, and V_c was increased an average of 60% in the 2 subjects studied. In 5 subjects repeated measurements of D_L, ventilation rate, systemic blood pressure, pulse rate and pulmonary blood flow (by a single breath acetylene method) were made before, during and after the period of hypercapnia. After starting to breathe the CO_2 enriched gas mixture, D_L rose abruptly, reaching near maximal values in 2-5 minutes, while the other measurements of respiratory and circulatory phenomena continued to rise for 6-10 minutes suggesting that the presumed increase in the pulmonary capillary bed was not directly dependent on the respiratory and circulatory changes. - Authors' Abst.

370. Roughton, F.J.W., Forster, R.E., and Cander, L.: Rate at which carbon monoxide replaces oxygen from combination with human hemoglobin in solution and in the red cell. J. Appl. Physiol. 11: 269-276, 1957.

The rate at which CO replaces O_2 in combination with human hemoglobin in solution and in red cell suspensions at 37°C was determined in vitro on the blood of six normal subjects at O_2 tensions from 100 to over 600 mm Hg, by means of modifications of the Hartridge-Roughton rapid reaction velocity apparatus, using either a reversion spectroscope or a two-color photocolormetric method. At low ratios of (CO) to (O_2) (i.e. <0.1), the rate of the reaction in Hb solution conforms theoretically to the equation $d(COHb)/dt = m'_{\kappa}(CO)(O_2Hb)/(O_2)$, where m'_{κ} is a true velocity constant. Experimentally, it was not possible to use ratios of

(CO) to (O_2) <0.2, and the results for Hb solutions were interpreted in terms of the equation $d(\mathrm{COHb})/dt = m'(\mathrm{CO})(\mathrm{O_2Hb}(/)\mathrm{O_2})$, where m' is an apparent velocity constant. The measured values of m' in Hb solution ranged from 6.8 to 22.4 $\mathrm{sec.}^{-1}$ as O_2 tension rose, the average value of m'_{∞} deduced therefrom being 18.8. The apparent velocity constant for cell suspensions, m'_c, is less than m' owing to the limiting effects of diffusion. The ratio of m'_c to m' rose from 0.46 at an O_2 tension of 100 mm Hg to 0.68 at an O_2 tension of 571 mm Hg. λ, the ratio of the permeability of the red cell membrane to that of the red cell interior, was calculated from these data to average 1.53. The values of m'_c calculated from the in vitro experimental results cannot be used directly for calculations related to in vivo pulmonary diffusing capacity experiments, because the CO tension is over 40-fold greater in the former. Corrections for this have been made and proper values of m'_c obtained for use in the calculation of true pulmonary diffusing capacity and pulmonary capillary blood volume. - Authors' Abst.

371. Shephard, R.J.: 'Breath-holding' measurement of carbon monoxide diffusing capacity. Comparison of a field test with steady-state and other methods of measurement. J. Physiol. (London) 141:408-419, 1958.

An adaptation of the portable box-bag suitable for breath-holding measurements of carbon monoxide diffusing capacity is described.

Repeated tests on six healthy normal subjects have shown that breath-holding D_{CO} varies in a non-linear manner with changes in total alveolar gas volume. During a deep inspiration D_{CO} may be doubled.

Some subjects find difficulty in holding breath steadily for 10 seconds, but vacillation of up to 200 ml. in alveolar gas volume do not measurably alter the calculated D_{CO}.

Comparison of the portable breath-holding apparatus with the steady-state method and with other types of portable equipment has yielded D_{CO} values that show a very similar coefficient of variation, but absolute values are larger by the breath-holding technique, probably on account of the larger alveolar gas volume during the test.

Steady-state determinations of fractional carbon monoxide uptake have a smaller coefficient of variation than any available method for the calculation of D_{CO}, and this approach still seems the best where a simple field test of pulmonary diffusion is required. - Author's Sum.

372. Shephard, R.J., Turner, M.E., Carey, G.C.R., and Phair, J.J.: Correlation of pulmonary function and domestic microenvironment. J. Appl. Physiol. 15:70-76 (Jan.) 1960.

Pulmonary pressures, total and timed vital capacity, functional residual capacity and carbon monoxide uptake have been correlated with temperature, humidity, suspended particulate matter and gaseous acid in a 3-month prospective survey of 10 cardiorespiratory cripples. Results have been analyzed by a sequential multiple regression technique, and significant relationships demonstrated between pulmonary function measurements and time, humidity and suspended particulate matter. The immediate response to suspended particulate matter was consistent with bronchoconstriction, although the most significant features were a transient depression of pulmonary pressures and carbon monoxide uptake. The prolonged depression of carbon monoxide uptake, starting 4 days after an intense episode of pollution, did not show itself as a significant long-lag coefficient for the survey as a whole; the existence of a threshold dose of suspended particulate to produce structural damage is postulated. - Authors' Abst.

373. Solvsteen, P.: Lung diffusing capacity: Cyclically and continuously ventilated closed systems. J. Appl. Physiol. 20:92-98 (Jan.) 1965.

In previous communications, distribution of ventilation and lung diffusing capacity (D_L) were calculated from changes occurring in N_2 and CO concentrations when a subject, whose lungs contained atmospheric air at the beginning of the experiment, respired in a spirometer containing oxygen and a little CO. In the calculations, the system was assumed to be continuously ventilated and without dead space. The present study examines which errors may arise from these simplifications. Equations for cyclic ventilation are derived. Definite values for dead space and for volumes, alveolar ventilation, and D_L of two nonuniformly ventilated lung regions are assumed. Thereupon it is computed how the concentrations of N_2 and CO will change, if a subject with the assumed values respire in a spirometer of a given volume. From these changes in concentration, D_L and the distribution of ventilation are calculated using equations for continuous ventilation. The differences between the assumed and the calculated values of D_L are small. - NASA 80309

374. Solvsteen, P.: Lung diffusing capacity: Rebreathing method, applicability in nonuniform ventilation. J. Appl. Physiol. 20:99-102 (Jan.) 1965.

Carbon monoxide concentration changes were calculated when subjects with different distributions of ventilation and lung diffusing capacity (D_L) respire in a small bag. The curve ($\log_e$ CO concentration in the bag) versus (time) will sooner or later appear as a straight line. The D_L is calculated from the slope of the rectilinear section of the curve and from lung and bag volume. If the curve becomes rectilinear within the period considered, D_L is calculated too low. In some cases the curve will not be rectilinear until more than 45 seconds have passed, but will appear to be rectilinear during the period from 30 to 45 seconds. If such an experiment is discontinued when 45 seconds (the usual duration of experiment) have passed, D_L can be calculated at too high, at correct, or at too low values. - Author's Abst.

375. Spicer, W.S., Jr., Johnson, R.L., Jr., and Forster, R.E. Diffusing capacity and blood flow in different regions of the lung. J. Appl. Physiol. 17:587-595, 1962.

We have measured the disappearance of CO and, in most instances, acetylene relative to helium from early and late portions of the expired alveolar gas after 1.5-20 sec of breath holding at rest in four normal subjects and seven patients with obstructive emphysema and three with sarcoidosis. In all individuals, except one patient with emphysema, graphs of the logarithm of the relative expired alveolar CO concentrations in early and late expired samples against time of breath holding were parallel, but those for the late expired samples lay below these for the early expired samples. The equality of the slopes of the two curves indicated that net diffusing capacity/alveolar volume for those regions of the lungs contributing to the two samples even in severe obstructive disease. The displacement of the disappearance curves can be explained by errors in estimation of the time the gas spends in the alveoli and by an increased rate of CO disappearance caused by reduced alveolar volume during expiration. - Authors' Abst.

375a. Spicer, W.S., Jr., and Kerr, D.H.: Variation in respiratory function. Arch. Environ. Health 12:217-226 (Feb.) 1966.

Daily measurement of the respiratory function of 17 patients with chronic obstructive pulmonary disease and of 11 normal subjects identified a day to day variation in the values obtained with the whole body pressure plethysmograph and with the spirometer.

A significant percentage of the variance in these tests can be explained by the tendency for subjects to change together on a week to week basis and for subjects within disease groups to change together from day to day. The pattern of change in lower airway conductance and certain other respiratory function tests may provide a more sensitive index of the normal or disease state than the customary battery of tests performed on a single occasion. Environmental factors, including air pollution and meteorological changes, would appear to fulfill the criteria of agents responsible for such patterns of change. - Authors' Sum.

376. West, J.B.: Diffusing capacity of the lung for carbon monoxide at high altitude. J. Appl. Physiol. 17:421-426 (May) 1962.

Diffusing capacity of the lung for carbon monoxide (Dl) was measured in London (Pb approx. 750 mm Hg), at 15,300 ft (4,700 m; Pb approx. 440 mm Hg), and at 19,000 ft (5,300 m; PB approx. 380 mm Hg) on seven members of the Himalayan Scientific and Mountaineering Expedition, 1960-61. At each altitude Dl was measured at two work levels (300 and 900 kg-m/min) and at three different inspired oxygen tensions in order to separate membrane and blood components of the diffusing barrier. A steady state method was used with mixed expired gas analysis; dead space-to-tidal volume ratio was assumed but calculated Dl was insensitive to this. There was no consistent change in Dl at 15,300 ft (subjects breathing ambient air) compared with sea level, but Dl was significantly increased after 7-10 weeks at 19,000 ft (mean changes of 15 and 19% for work levels of 300 and 900 kg-m/min, respectively). However, this small change in Dl can be wholly accounted for by the increased rate of reaction of carbon monoxide with hemoglobin due to hypoxia and by the increased blood hemoglobin concentration. - Author's Abst.

377. Woolf, G.R.: An assessment of the fractional carbon monoxide uptake and its relationship to pulmonary diffusing capacity. Dis. Chest 46:181-189 (Aug.) 1964.

The fractional carbon monoxide uptake (FUco) and pulmonary diffusing capacity (Dco) were measured in 48 normal subjects at rest and during exercise.

Measurements at rest were made in 64 patients with chronic chest disease and in 35 of these the tests were repeated during exercise. A modification of the Bates steady-state technique for estimating diffusing capacity is described.

The FUco showed no significant differences between men and women and there was no relationship to body surface area. There was a decrease in the FUco at rest with increasing age, but this relationship was not present when the FUco was measured during exercise.

The normal FUco had a narrower range than Dco and was relatively little affected by voluntary hyperventilation. The FUco at rest and during exercise in the same individual agreed well irrespective of whether the result was normal or abnormal.

A normal FUco corresponded with a normal Dco, and a low Dco was always associated with a low FUco. Where the FUco was low and the Dco was normal, evidence is presented which suggests that the FUco revealed an abnormality of gas exchange which was not shown by the Dco. - Author's Sum. Modified

378. Young, W.A., Shaw, D.B., and Bates, D.V.: Effect of low concentrations of ozone on pulmonary function in man. J. Applied Physiology, 9, 4, 765-768 (July) 1964.

Describes results of measurements of pulmonary function made on 11 subjects in 16 experiments breathing ozone (0.6-0.8 ppm) through mouthpiece for 2-hour periods. Ozone produced highly significant reduction in steady-state DL_{CO} (diffusing capacity of lung for carbon monoxide). Vital capacity and expiratory flow rates may be limited in part by tracheobronchial irritation that follows inhalation of 0.6 ppm of ozone for 2 hours. - CBK

Neurological Changes

379. Beard, R.R., and Pribram, K.: Effects of toxic agents and environmental factors on human behavior. Department of Defense, Armed Forces Epidem. Board, Washington, D.C., Feb. 1964, DDC No. 438409.

Dynamic esposure chambers have been constructed in which an air flow of up to 100 liters per minute can be maintained. Carbon monoxide has been metered to the chambers under continuous monitoring, to expose rats to concentrations from 100 to 1,000 p.p.m. Rats were trained to various operant behavior schedules. Conditioned behavior during 10 minutes of each hour for long periods gave unstable response patterns. Continuous observation for periods of 1-1/2 hours showed rapid reduction of response rate and disturbance of the "grain" of behavior with CO concentrations of 500 p.p.m. and higher; at 250 p.p.m. perceptible disturbance of response pattern became apparent within an hour. A response-attenuation ratio taking into account the normal behavior of an animal on the day of exposure to CO as well as preceding control periods was devised. Equipment for trials of the effect of CO on discrimination capacities in humans has been developed. Methods for detailed analysis of behavior patterns by computer techniques are being perfected. - Authors' Abst.

380. Borman, M.C.: Carbon monoxid poisoning. Mental and neurological changes in a case of acute carbon monoxid poisoning with partial recovery. Amer. J. Psychiatry 6:135-143, 1926.

A case of accidental carbon monoxid poisoning is reported in which the patient showed evidence of wide-spread central nervous system changes from which there was apparent recovery, followed again by numerous mental and neurological disturbances with ultimate recovery, except for the mental state.

The chemical alterations in the blood and clinical tests thereof in carbon monoxid poisoning are mentioned.

The anatomical changes in the central nervous system following carbon monoxid poisoning are discussed together with the various explanations offered for their occurrence. - Author's Sum.

381. Chalupa, B.: Disorders of memory in acute carbon monoxide intoxications. Pracovni Lékař. (Prague) 12:331-336, 1960.

The author presents an account of experimental examinations of the memory in a group of 44 persons who had recently suffered from acute CO intoxication. The average age was 35.6 yrs. The following methods were used: repeating 20 separate words, recognition of same material with control items, or repeating 30 verbal pairs having some relationships as to their content. The disturbances of memory manifested themselves by an affection of logic memory and difficult differentiation when attempting to recognize; mechanical memory was relatively intact. When evaluating the results in individual persons examined pathological changes of memory structure were revealed in 26 (59.1%). These findings were most frequent in a group of accidental acute and subacute CO intoxications (78.6%) though loss of consciousness was noted in only 21.6%. In suicidal CO intoxications, which in all instances were associated with loss of consciousness, pathological deviations were found in 54.4%. Differences in the affection are explained by the different conditions of exposure and the different methods of treatment of the patients investigated. In addition to concentration of CO, the time of exposure must be taken into account, this being particularly important in industrial and accidental CO intoxication where frequently protracted acute and subacute exposures with pathological findings occur though they are not associated with loss of consciousness. A comparison with COHb levels on admission revealed in 22 patients a positive correlation with the reduction of logical memory and with some indicators in the experiments on recognition. At COHb levels up to 29.9% disorders of memory were found in 33.3% at levels of 30-78%, in 61.5% of all cases. Repeated examinations after intoxication had subsided showed that logical memory and recognition had returned to normal and mechanical memory remained on the same level. From the present work some practical suggestions can be drawn for the prevention and assessing of toxic changes of the central nervous system after acute CO poisoning. - APCA 4835.

382. Courville, C.B.: The process of demyelination in the central nervous system. IV. Demyelination as a delayed residual of carbon monoxide asphyxia. J. Nervous Mental Dis. 125:534-546, 1957.

In this study of a series dealing with the process of demyelination, the changes in the cerebral and cerebellar centrums have been noted following severe asphyxia incident to carbon monoxide. Such changes are "delayed" in the sense that a suitable time interval must elaspe after the asphyxial episode, 76 days in the case herein reported. The characteristic alterations constituting the residual lesions were 1) perivascular demyelination as the initial lesion, leading to 2) diffuse demyelination by confluence of these individual foci, 3) the tendency to spare the subcortical arcuate fibers, 4) vascular changes in the form of a decrease in number of capillaries in the degenerative foci, and a progressive collapse and disappearance of the arterioles in the affected area, 5) a decrease in the number of oligodendroglia in the degenerative areas, 6) the obvious secondary nature of loss of myelin being an effect of ischemia and 7) the occasional occurrence of islands of preservation in the periphery of the lesion.

The findings are significant in their remarkably close correlation to the changes observed in diffuse sclerosis. But in addition, there was found evidence of support for the conclusion that demyelination per se is very likely a secondary process, probably never a primary one. It is also very likely that the loss of oligodendroglia in areas of demyelination (i.e., the plaques of multiple sclerosis) is due to their sensitivity to ischemia (local anoxia) and bears no cause-effect relationship to the process of demyelination. - Author's Sum.

383. Dorcus, R.M., and Weigand, G.E.: The effect of exhaust gas on the performance in certain phychological tests. J. General Psychol. 2: 73-96 (Jan.) 1929.

Authors state that the increase in the number of automobiles and trucks and the accompanying increase in the exhaust gas caused thereby has given rise to some new physiological and psychological problems. These problems involve both the immediate and the cumulative effects upon the human organism.

In order to ascertain such effects, six medical students were exposed daily to exhaust gas for a period ranging from about 3-1/2 to 6 hours, except for certain control days.

The psychological tests employed in this investigation were steadiness, tapping, dynonometer, substitution, arithmetic, location memory, and the so-called Felix test. In the summary, authors state that it might be concluded that no significant difference in performance was found after exposure to exhaust gas-air mixtures which contained 2, 3, and 4 parts of CO per 10,000 of air for periods ranging from 3 to 5 hours and which caused 25 to 35 per cent of the hemoglobin to be in combination with CO. Although there was a slight tendency for a poorer performance to be made on the prolonged steadiness test, the difference in performance on all the other tests used was no greater than the variation in performances on successive control periods.

The necessity for more work in this area is emphasized. - AGC

384. Duvoir, M., and Gaultier, M.: Etiology: Clinical and chemical study of forty cases of chronic industrial carbon monoxide poisoning. Arch. Mal. Prof. 7:449-452, 1946.

Scepticism concerning the reality of chronic CO poisoning has been justified by the multiplicity of symptoms attributed to the disease. This paper attempts to establish chronic CO poisoning as a reality and as an individual disease by establishing a clinical and chemical basis.

Using Nicloux' method to determine the amount of CO in 40 subjects, a blood level above .4 to .5 cc. per 100 cc. blood is considered abnormally high. Cessation of exposure resulted in a gradual reduction of the blood level. In two months, one subject went from .85 to .52, another from 2.5 to .52, another from .82 to .46, etc. The blood level persisted for a longer time in a number of cases, a typical case being: .88 after exposure, .80 after 3 months, .30 after 5 months. Rest alone results in improvement, but oxygen therapy accelerates recovery. Vitamin B_2 also hastens return of blood levels to normal although its action is neither immediate nor constant.

Chronic CO poisoning is characterized by this elevated blood level and by three major symptoms, always appearing together. These are, 1) Asthenia. The asthenia is almost constant. Muscular fatigue, intellectual apathy, depression, slowness of speech, and impaired memory are frequently found, and sexual impotence is occasionally concurrent. 2) Severe headache. The headache is persistent, and usually more severe during exposure, although it may continue for several hours after work. It is not localized to any specific brain area. 3) Vertigo and syncope. Vertigo is frequent and may signal syncope. Syncope is a less important differentiation, since it is so often found in acute poisonings.

Pathogenesis and mechanisms remain obscure, but determination of blood level of CO, the constancy of symptoms, and improvement occurring during cessation of exposure are indicative of the reality of chronic CO poisoning.

385. Fisher, B.M., and McFarland, R.A.: Some psychological effects of automobile exhaust gases. Presented at the Fourth Annual Air Pollution Medical Research Conference, San Francisco, Calif., Dec. 7-9, 1960.

Background of current problem is to be found principally in studies of altitude-induced anoxia. There are few studies which include CO as independent variable. Complex behavior processes such as learning, remembering, problem-solving, show little evidence of deficit at altitudes below 10,000 feet (equivalent to about 10% CoHb). Personality changes, such as reduction in self criticism and gross disturbances of motor control are not usually evidence below altitudes of 15,000 feet. Auditory function has shown no significant change with moderate altitude but visual functions have shown changes at 5,000 feet. (3-4% CoHb.) Effect on visual thresholds of breathing CO lasts longer than residual CoHb will justify. - Authors' Abst.

386. Gilbert, G.J., and Glaser, G.H.: Neurologic manifestations of chronic carbon monoxide poisoning. New England J. Med. 261:1217-1220 (Dec. 10) 1959.

A detailed case history is given of a patient suffering from chronic carbon monoxide poisoning. The condition was verified by the finding of a significantly-elevated blood carbon monoxide level. A detailed occupational history was obtained indicating that the patient had been a policeman for 18 years. His first few "spells" had occurred four years before hospital admission in 1958 at the age of 50 while he was assigned to directing heavy automobile traffic. Fearing that his job was too strenuous, he had requested transfer to the police garage and had served as a mechanic there for the past three years. It was often necessary to run the motors of the police cars in the garage, particularly in the repair of police radios which required a running motor for their operation. The garage doors were usually left open but were close often after March to keep out the sun. The time of closing of the garage doors corresponded to the period of exacerbation of the patient's symptomatology. The patient had anorexia, weight loss, a fluctuating organic mental syndrome, and recurrent episodes of loss of consciousness, each attack preceded by a period of dizziness and ataxia. After the patient had discontinued his work, serial electroencephalograms showed progressive clearing of focal and paroxysmal abnormalities, correlated with clinical improvement. It is noted in the text--and commented editorially, in the same journal, pp. 1248-1249--that unless the occupational history is carefully taken, the different diagnoses can be difficult. The patient under discussion had received anticonvulsant therapy for 2-1/2 years previous to the correct diagnosis. It is noted in the editorial also that there were a few more attacks which were always associated with driving a farm tractor. It was found that the patient had a habit of walking behind the tractor where the exhaust was on a level of about his head. When this occupation was also discontinued he recovered fully, and the diagnosis was confirmed. - APCA 3185

387. Gilinskiy, V.A., Chapek, A.V., Kozlova, A.G., Kulikova, N.M., and A. Ya. Loshak: The effect of low concentrations of carbon monoxide on man in pressurized cabins of passenger planes. In: Parin, V.V. (editor) Aviation and Space Medicine, Moscow, 1963. NASA Technical Translation TT-F-228.

Pressure-chamber experiments were performed on 82 persons to study the effect of low concentrations of carbon monoxide. Also, 30 flights on IL-18, AN-10, and TU-104 planes were made during which 185 members of the crew and passengers were examined and 347 air samples were obtained in the cabins. The results of the investigations showed that 3 hours' exposure to carbon monoxide (starting with 0.01 mg/liter or more), both under experimental conditions (ground and pressure-chamber at 2400 m) and during actual flight had adverse effects on the functioning of several organs and systems, namely: (a) Higher nervous activity; (b) Functions of the visual and vestibular analyzers; (c) Metabolic processes; (d) Cardiovascular system; (e) Muscular strength, (f) Tissue respiration and; (g) Leukopoiesis. On the basis of the physiological-sanitary data obtained and the results of laboratory tests, it is suggested that the maximum permissible concentration of carbon monoxide in pressurized passenger airplane cabins be 0.01 mg/liter. - Authors' Abst.

388. Grigor'ev, Z.E.: Effect of volatile substances and of gases on the higher nervous activity of white rats in the course of inhalation exposure. Farmakologiya i Toksikologiya 18:49-52, 1955. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 5, 1961, pp. 125-130, CFSTI-TT-61-11149, U.S. Dept. of Commerce, Springfield, Va.

The author describes attempt to evolve a method of experimental investigation which would permit the development of conditioned reflexes and inhalation exposure in one chamber. The following tests made in stages are described. Development of positive motor-nutrition conditional reflex with red light; development of inhibition differentiation conditioned reflex to white light; extinction and conversion of positive food conditioned reflexes into inhibition reflex response, and the latter into positive reflex response, and testing the effect of gasoline vapor on the higher nervous activity of rats. This method was applied for the determination of the minimum gasoline and carbon monoxide concentration affecting the central nervous system and it proved sufficiently sensitive in studying the action of other volatile chemical substances used in the different industries. - AGC

389. Grudzinska, B.: Electroencephalographic patterns in cases of chronic exposure to carbon monoxide in air. Folia Medica Cracoviensia 3: 493-515,1963.

The purpose of this study was to ascertain whether chronic exposure to CO produces pathologic changes in man and to analyse electro-clinical correlations. Sixty workers from gas works and coking plants exposed to CO concentrations not exceeding 0.01% were studied. The control group consisted of 30 workers similarly employed but not exposed to CO. Only healthy individuals were included in both groups without history of cranial trauma or acute CO poisoning. Examination included determination of erythrocyte counts, Hb and COHb levels, complete history, functional tests of the vegetative nervous system. EEG's were made at rest and after activities. CO exposure was confirmed by examination of COHb. The mean level of COHb was 7.4% in the exposed group, and 3% in the control group. The COHb level exceeded 10% in 11 persons of the exposed group. A neurasthenia syndrome was diagnosed in 63% of the exposed group and in 40% of the control group. The type and intensity of complaints in each group was studied. Statistical analysis of the differences revealed significantly greater incidence of headache and general debility in the exposed group.

Among the normal tracings from the exposed group there was a significantly higher proportion of flat, low-voltage tracings with scanty alpha rhythm ($p < 0.01$).

Statistically significant electroclinical correlations were found in the group exposed to CO. All the pathologic tracings and 81% of the low-voltage tracings and those with scanty alpha rhythm were found in individuals with neurasthenic syndromes. In addition, all the tracings of the first sleep phases were also found in neurasthenic individuals.

From the findings it may be concluded that chronic exposure to low concentrations of carbon monoxide does not cause distinct changes in the nervous system, but may have a certain inhibitory effect on the bioelectric activity of the brain, manifested clinically as neurasthenia and in the EEG as scantly low-voltage alpha rhythm and tracings of the first sleep phases. However, since these changes are nonspecific, EEG examination in cases suspected of chronic CO poisoning is not decisive, although it may be auxiliary factor in making the diagnosis. - Author's Sum. Modified

390. Kirichinskaya, I.A.: Sequelae of severe carbon monoxide poisoning. Soviet. Meditsina 22:152-154, 1958. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 5, 1961, pp. 115-119, CFSTI-TT-61-11149, U.S. Dept. of Commerce, Springfield, Va.

Carbon monoxide poisoning is characterized by acute impairment of the central nervous system functions, caused by carboxyhemoglobin formation and by disturbed brain cell oxygen metabolism. Author describes a case where the victim was in an atmosphere containing CO for about 12 hours. The severe carbon monoxide poisoning of this middle-aged male described, followed a favorable course at first: during 5 days of hospitalization his condition improved to such an extent that he was sent home and allowed to return to work after 4 days. Nine days later he began to manifest mental changes which necessitated his confinement to a psychiatric hospital. Akinetic syndrome with symptoms of diffuse damage of the cerebral vessels were diagnosed. Author suggests that persons with carbon monoxide poisoning should be under prolonged observation and hospitalized for not less than a month after intoxication. - AGC

391. Kovnatskyy, M.A.: Clinical study of chronic intoxication with carbon monoxide. Gigiena Truda Professional Zabolevaniia (Moscow) 5:25-30, 1961.

The paper contains a detailed discussion of the problem relating to chronic intoxication with carbon monoxide. Experimental data published in literature sources and many years of clinical observations prove that a prolonged period subjected to the effect of carbon monoxide may give rise to a chronic intoxication. The paper lists symptomatology of chronic intoxication, early manifestations of the poisoning, and curative-preventive measures. Special attention is given to the description of changes occurring in the nervous and the cardiovascular systems. - APCA 4366

392. Lumio, J.S.: Symptoms in the inner ear associated with chronic carbon monoxide poisoning. Arch. f. Gewerbepath. u. Gewerbehyg. 13:139-144, 1954.

Giddiness in 85% of the cases of chronic generator gas poisoning in Finland is often associated with otological disorders, vestibular or cochlear. Actual slight defect in hearing occurred only in 48% of these cases. There was a coincidence in 90% of positive oto-neurological cases with a reduction in the visual field as reported by Helminen. - PHS-RG 5676

393. **Lumio, J.S.: Hearing Deficiencies Caused by Carbon Monoxide (Generator Gas). Acta Oto-Laryngologica Suppl. LXXI, Helsinki, May 1948, 112 pp.**

This paper deals with the investigation of possible hearing disturbances due to exposure to carbon monoxide.

Chapter one gives a short review of the origin and development of the CO poisoning problem in Northern European Countries. Chapter two is a review of previous investigations and in chapter three author discusses his own investigations, on the basis of which author states that chronic CO poisoning seems comparatively often responsible for the impairment of hearing.

Seven hundred patients suffering from chronic CO poisoning were examined. Hearing disturbances were ascertained in 73.3% of the patients. A considerable smaller number of hearing disturbances, namely 26.7%, were found in patients who had been exposed to CO in their places of work, but in whom chronic CO poisoning could not be verified. - AGC

394. Malorny, G., Fodor, G., and Pomp, H.: Effect of low CO-concentrations on movement and reflexes. Arch. Experiment. Pathol. & Pharmacol. 246:23-24, 1963.

Tests were conducted with rats and mice for the determination of whether very low CO-concentrations contained in the atmosphere and inside working places can cause physical or psychological disturbances. The swimming performance of mice put into water and exposed for one hour to CO-concentrations of 0.03-0.05 Vol. % was much slower than the performance of control animals. The same slow performance was observed with animals put into water 2 hour after having been exposed to CO.

In testing spontaneous movements of mice the animals were placed into an air tight container into which alternating quantities of CO (160, 84 and 55 ppm) were piped in. After a 14 hour exposure the mice were put into a thread wheel and again exposed to CO for three hours.

In comparison with control animals running 1500 m in three hours, those exposed to 84 ppm CO were running 750 m and those exposed to 55 ppm 500 m during the same period of time.

The reaction of rats was tested after an exposure to 140-160 ppm CO. Tests were made 6 hours after exposure. Complete loss of reflexes was noted after 10 weeks. Since these disturbances remained for a long time after tests were completed, author assume that the central nervous system had been permanently damaged. - From German-AGC

395. Raskin, N., and Mullaney, O.C.: The mental and neurological sequelae of carbon monoxide asphyxia in a case observed for fifteen years. J. Nerv. & Mental Dis. 92:640-659 (Nov.) 1940.

Author describes the mental and neurological sequelae of a patient who survived, for 15 years, a case of CO asphyxia. This patient developed Parkinsonian's syndrome, and the mental picture was one of involution melancholia. The extensive literature of case studies of patients who survived CO poisoning for a few days or months is also reviewed. - AGC

396. Shillito, F.H., Drinker, C.K., and Shaughnessy, T.J.: The problem of nervous and mental sequelae in carbon monoxide poisoning. J. A.M.A. 106:669-674 (Feb. 29) 1936.

The New York metropolitan area was chosen for a study of nervous and mental sequelae of carbon monoxide poisoning. It is known that at least 21,143 acute exposures of all degree occurred there in a ten year period. For the same period a survey of the state mental institutions serving the meteropolitan area of New York City showed thirty-nine certain cases of sequelae of carbon monoxide. Such patients formed 0.05 per cent of the total admissions. Serious mental or nervous sequelae of carbon monoxide poisoning are thus infrequent in relation either to other nervous and mental diseases or to the number of acute exposures.

Study of case records reveal that when nervous or mental damage occurred the acute carbon monoxide intoxication was extreme. Complete unconsciousness was invariable and the most active resuscitative measures were necessary. None of these cases followed so-called chronic carbon monoxide exposure over a long period of time.

A clear period of from seven to twenty days preceded the onset of symptoms in one third of the cases. In the remainder of the cases the symptoms started immediately following the poisoning.

Mental sequelae consisted of a confusion psychosis, with disorientation, lack of judgment and amnesia. Motor overactivity and aphasia were much less common. Hallucinations, delusions or convulsions played no conspicuous part.

Nervous sequelae consisted of signs varying from slightly increased deep reflexes to well advanced parkinsonism. Sensory disturbances, such as skin anesthesia and peripheral motor neuritides, were also encountered. These cases all showed improvement, but the final result depended on the degree of initial damage.

In the total group of forty-three cases, twenty-three patients recovered completely, nine suffered permanent nervous or mental sequelae and eleven died. - Authors' Sum.

397. Shillito, F.H., Drinker, C.K., and Shaughnessy, T.J.: Contributing causes in CO poisoning. Amer. Gas Ass. Monthly 18:260-261 (Mid-Summer) 1936.

From 528 cases of recent carbon monoxide exposure, 167 cases were hospitalized after emergency treatment. The records of these patients were studied and serve as the basis of this report.

In regard to contributing causes, two thirds of the patients gave evidence of pre-existing psychoses, acute alcoholism or serious organic diseases.

Considering the mental and physical background of the group, it is not surprising to find an 82.6 per cent suicidal rate.

The incidence of nervous and mental after-effects of acute carbon monoxide poisoning was found to be slightly higher than previously reported (0.56 per cent as compared with 0.18 per cent). This difference may be due to different methods of study, or to the fact that modern methods of treatment are reviving more seriously poisoned cases. - Authors' Sum.

398. Strecker, E.A., Taft, A.E., and Willey, G.F.: Mental sequelae of carbon monoxide poisoning, with reports of autopsy in two cases. Arch. Neurol. & Psychiat. 17:552-560, 1927.

This paper presented before the Philadelphia Neurological Society, refers to previous presentations and studies reporting pathologic changes in the central nervous system caused by carbon monoxide poisoning. Studies by scientists who examined thirty-two brains report similar conditions as presented in these papers, consisting of characteristic symmetrical softening of the globus pallidus, with degenerative changes in the arterial walls leading to the deposit of lime salts even by the third day. Considerable confirmatory, experimental work was done with animals by another investigator. Authors' relate studies of two cases made in the wards and laboratories of the department for mental and nervous diseases of the Pennsylvania Hospital. - AGC

399. Strzelczyk, P., and Zenk, H.: Permanent sub-toxic effects of carbon monoxide on organs connecting hearing and balance in gas workers. Archiv Ohren-, Nasen- u. Kehlkopfheilk. 184:81-92, 1964.

Early diagnosis of slow developing chronic CO poisoning is discussed in this paper. Investigations of subjective complaints of workers exposed to CO concentrations of 0.01% and above were made in addition to audiometric and vestibular function tests. Although the effects of acute CO poisoning have been recognized, there are still divided opinions as to damaging health effects following continuous or intermittent exposure to this gas. Experiments with two groups of workers, one group exposed to low CO content and one control group exposed to clean air, were made. Standardized methods of investigation were used, which made it possible to obtain objective results of pathologic changes. Eighty-four percent of the CO group had subjective complaints in comparison with 47% in the control group. The investigations showed a significant difference of subjective audiometric and vestibular symptoms. The noise-audiometry showed that six cases suffered cortical, and four cases retro-ganglion damage. A significant difference in subjective audiometric and vestibular symptoms were noted, caused by sub-toxic doses of CO, in comparison with the control group. - From German-AGC

400. Tronzano, L., and Coscia, G.: Radial paralysis in a case of acute carbon monoxide intoxication. Rass. Med. Indust. 33:401-403 (May-Aug.) 1964.

A case is reported of paralysis of the right arm in a 38-year-old worker acutely poisoned by carbon monoxide. The paralysis persisted for three months, although no signs of central-nervous-system distress were evident. This case demonstrates the occurrence of isolated lesions in the peripheral nerve trunks of the arm during acute carbon monoxide poisoning. - NASA 80287

401. Vol'fson, Z.G.: Limits of allowable concentration of carbon monoxide in atmospheric air. In: Levine. B.S. (translator) and Ryazanov, V.A. (editor): Limits of allowable Concentrations of Atmospheric Pollutants. U. S. Office of Technical Services, Washington, D. C., Book 1, 1952, pp. 56-64. OTS 59-21173.

The U.S.S.R. literature on studies concerning CO in the atmosphere is reviewed in this paper. Based on clinical and experimental evidence 20-30 mg/m^3 of CO are considered maximum levels at which disturbances in the central nervous system are noticeable. The recommendation for the adoption of standards was made after thorough study of results of investigation and experiments. The population surveyed consisted of children, aged, sick, and generally feeble persons. Following recommendations were made: The maximal allowable limit of average daily CO concentrations in the city atmosphere is not to be above 2 mg/m^3. Maximal single concentration of CO in the atmospheric air must not exceed 6 mg/m^3. - AGC

402. Von Oettingen, W.F.: Carbon Monoxide: Its Hazards and the Mechanism of its Action. Federal Security Agency, U.S. Public Health Service, PHSB No. 290. U.S. Government Printing Office, Washington, D. C., 1944, pp. 257.

Investigations by the author show that CO poisoning is characterized by the formation of CO hemoglobin and that the amount of CO hemoglobin formed depends upon the concentration of CO in the air, the duration of the exposure, and the rate of respiration of the individual exposed. An increase in the temperature, humidity, and CO_2 content of the air or a decrease in the concentration of O_2 will stimulate the respiration and hence favor the absorption of CO. But if such variations are eliminated, certain concentrations of CO in air will convert only a definite percentage of oxyhemoglobin into CO hemoglobin until an equilibrium is reached. The speed with which the maximal concentration is reached depends upon the concentration of CO in air, so that with high concentrations of CO maximal saturation may occur very rapidly.

CO may also react with other "heme"-containing pigments and enzymes, but, of all pigments mentioned, only the pseudohemoglobin has a greater affinity to CO than hemoglobin, and at present it appears impossible to judge on the physiological importance of this phenomenon. The question as to whether or not CO affects the functioning of other pigments such as myoglobin or cytochrome appears to need further study, and the same holds true regarding information on the effect of CO on certain pigments found in the brain.

Regarding the relation between toxic symptoms and the concentration of CO hemoglobin in the blood, it appears that concentrations below 20 percent cause only moderate subjective complaints and that these become serious with concentrations up to 30 percent and alarming with higher concentrations. It appears impossible to state which concentration of CO hemoglobin in the blood will be fatal because this will vary considerably with the type of exposure and the O_2 need of the organism at the time of the exposure, but it appears that concentrations between 60 and 80 percent will be dangerous to life.

Analysis of the clinical picture and the pathological findings in CO poisoning, especially in regard to the behavior of the circulatory apparatus and the central nervous system as well as the metabolism, appears to indicate that the sequelae of CO poisoning are more serious than would be expected from mere anoxemia of a similar degree. In spite of the impressive parallelism between the effects of CO poisoning and those produced by lack of O_2 it cannot be denied that there are a number of reactions and phenomena which may indicate a specific primary or secondary effect of CO on certain "heme"-containing pigments or enzymes of the organism. - Author's Conclusions Modified.

403. Wechsler, I.S.: Partial cortical blindness with preservation of color vision. Arch. Ophthalmol. 9:957-965, 1933.

This is a report of a case following possible CO asphyxiation, whereby the patient suffered a brain lesion in which the cortex was extensively affected. It has been established by clinical observation and pathologic studies that cortical and subcortical lesions may give rise to dissociation of color perception from visual acuity, namely, loss of former without impairment of the latter; it is also well known that in impairment of vision, whether peripheral or central, the first to be lost and the last to be regained is the perception of color.

Author points out that CO has a predilation for the basal ganglious, especially causing lenticular softening, and for the peripheral nerves, but no part of nervous system is immune to the poison. Parkinsonian syndromes and peripheral nerve palsies frequently characterize CO poisoning. Mental deterioration and psychotic manifestations so commonly encountered attest the additional cortical involment, as well as Parkinsonian syndromes and peripheral nerve palsies. - AGC

404. Wilmer, W.H.: Effects of carbon monoxid upon the eye. Amer. J. Ophthalmol. 4:73-89 (Feb.) 1921.

This paper gives a general survey of the subject and includes a graphic description of the subjective and general nutritional effects of carbon monoxid poisoning, by one of the victims; and incidentally throws light on the origin of a story of a haunted house. It gives an account of the ocular symptoms of such poisoning, revealing a distinct tendency of the poison to cause neuritis and especially to affect the optic nerve. - Author's Abst.

Postmortem Investigations

405. Campbell, J.A.: Hypertrophy of the heart in acclimatization to chronic carbon monoxide poisoning. J. Physiol. 77:8P-9P, 1933.

In the course of the post-mortem examinations of tar-cancer mice, some of which had been exposed for about 9 months to chronic carbon monoxide poisoning and others for the same period to oxygen at high pressure (60 p.c. atmos.) in the air, it was observed that the average weight of the hearts of the mice exposed to carbon monoxide was much greater than that of the mice exposed to high oxygen and also than that of the control mice. Only one of the controls and two of the mice exposed to high oxygen possessed hearts weighing more than 0.235 gm. Of the 19 mice exposed to carbon monoxide, 14 possessed hearts weighing between 0.235 and 0.340 g.; in 4 others the weights were between 0.200 and 0.235 g.; 0.435 g. was the weight of the heart in the remaining mouse. - Author's Abst.

406. Candura, F., Craveri, A., and Brasca, F.: Fibrinolysis in acute carbon monoxide poisoning. Experimental research. Folia Med. (Naples) 44:400-408 (May) 1961.

In experiments with rabbits, the authors studied the fibrinolytic behavior of the blood serum following acute or fatal poisoning with city-gas (CO content of 1.8-5%). A constant and significant increase in the content of fibrinolysin or plasmin, was found. This resulting increase in the fibrinolytic power of the blood may explain the occasional finding of a fluidity of the post-mortem state of the blood following a CO-poisoning death. No correlation was found between the rate of increase of fibrinolysis and the blood hemoglobin CO (HbCO) level. In view of the absence of any correlation, it is suggested by the authors that post-mortem blood fluidity--a finding which is not wholly characteristic of CO poisoning--might occur through nonspecific mechanisms which are brought into action by stress. - APCA 4255

407. Dominguez, A.M., Halstead, J.R., and Domanski, T.J.: Determination of Carboxyhemoglobin in Decomposed Bodies. Armed Forces Institute of Pathology, Washington, D.C., July 1963, 15 pp. DDC AD 420631.

The interpretation and the significance of carbon monoxide findings in cases associated with decomposition is studied. The evidence presented indicates that the percentage of carboxyhemoglobin saturation value is not markedly altered during postmortem decomposition when: (1) the specimens are properly preserved, and (2) the blood extracted from tissue is examined as soon as possible for the presence of carbon monoxide. It appears possible to obtain carbon monoxide values, utilizing blood extracted from tissue, in the presence of postmortem decomposition that are similar to the antemortem levels. For example, within the 4% to 12% carboxyhemoglobin-saturation range covered, there was neither a marked increase nor decrease in final percentage of carboxyhemoglobin following decomposition. Nevertheless, unreliable carboxyhemoglobin saturation values may occur. A gas-solid chromatographic procedure for determining carbon monoxide using blood or tissue is presented. This procedure employs a Van Slyke apparatus for liberating gases from biological specimens modified for introducing released gas into the gas chromatograph. - Authors' Abst.

408. Glantz, W.M., Stembridge, V.A., Dominguez, A.M., et al: Carbon monoxide determination in aircraft accident fatalities. Aerospace Med. 30:711-715 (Oct.) 1959.

Investigators at the Armed Forces Institute of Pathology have studied 747 cases of aircraft accident fatalities for the presence of carbon monoxide in postmortem tissues. All aircraft accident victims with carboxyhemoglobin elevations above 10 per cent were shown to have been alive at the time of the fire. Carboxyhemoglobin levels between 6 and 9 per cent saturation indicate the possibility that the subject was alive at the time of exposure to fire. Extensive fragmentation and postmortem incineration of tissues subsequent to explosive impact forces do not elevate the carboxyhemoglobin saturations. These investigators found no cases in which carbon monoxide intoxication has been implicated as the cause of an aircraft accident. - Authors' Sum.

409. Hayhurst, E.R.: Carbon monoxide and automobile exhaust gases. Amer. J. Pub. Health 16:218-223 (March) 1926.

This paper deals with the problem of diagnosis of carbon monoxide poisoning, but not with cases where exposure is evident and severe symptoms or death ensue. Author is interested in exposure to limited amounts and whether such symptoms as the common ones of headache, weariness, weakness, dizziness, nausea, vomiting, loss of strength and muscular control, increased pulse and respiratory rates, loss of reflexes, and even coma with intermittent convulsions, cessation of respiration, and death are due to carbon monoxide poisoning or any of the many other possible factors connected with the environment or the condition of the victim. - Author's Abst. Modified.

410. Ramsey, T.L., and Eilmann, H.J.: Carbon monoxide acute and chronic poisoning and experimental studies. J. Lab. & Clinical Med. 17: 415-427, 1931-1932.

Presented is a study of carbon monoxide from a standpoint of the method of its production, its affinity for hemoglobin, its action upon being respired, the percentages of blood saturation in varying lengths of time according to the concentration in the respired air, the symptoms and effect upon the body, possible methods of its elimination from the body, the production of chronic carbon monoxide poisoning, methods of treatment, the postmortem macroscopic appearances of the body following carbon monoxide deaths, some important medicolegal facts, a series of experiments on guinea pigs to ascertain its persistence in the body following exposure, and the histopathology of various tissues in animals dying, directly during exposure, and those killed and autopsied at varying periods later. - Authors' Sum.

411. Stembridge, V.A., and Goldbaum, L.R.: The role of the Armed Forces Institute of Pathology in tissue toxicity study. Aviation Med. Symposium, Nov. 1957, pp. 5-8.

During the period from May 1957 through Oct. 1957, 269 determinations for CO have been accomplished at the Armed Forces Institute of Pathology utilizing a new method for obtaining a specimen. Of those 110 determinations for carbon monoxide on post-mortem tissues, 11 (10%) showed an elevation above 10 percent saturation. None of these 11 cases were considered a sudden death and in all there was evidence that the individual died primarily due to fire.

Post-mortem CO determinations are done in aircraft accident victims for two basic reasons: First, to determine whether carbon monoxide was present in the cockpit environment prior to impact (due to such factors as in-flight fires, exhaust fumes or improper venting of other combustion products) and second, to determine whether or not an individual was alive following an impact associated with fire. - From Text-AGC

412. Strecker, E.A., Taft, A.E., and Willey, G.F.: Mental sequelae of carbon monoxide poisoning, with reports of autopsy in two cases. Arch. Neurol. & Psychiat. 17:552-560, 1927.

This paper presented before the Philadelphia Neurological Society, refers to previous presentations and studies reporting pathologic changes in the central nervous system caused by carbon monoxide poisoning. Studies by scientists who examined thirty-two brains report similar conditions as presented in these papers, consisting of characteristic symmetrical softening of the globus pallidus, with degenerative changes in the arterial walls leading to the deposit of lime salts even by the third day. Considerable confirmatory, experimental work was done with animals by another investigator. Authors' relate studies of two cases made in the wards and laboratories of the department for mental and nervous diseases of the Pennsylvania Hospital. - AGC

413. Tamas, A., and McElroy, J.: Postmortem Carbon Monoxide Analysis: Significance of Tissue Blood Content. Aerospace Medical Research Lab., Wright-Patterson AFB, Ohio, Nov. 1957, 15 pp. (tables) DDC AD 142 150.

Proper interpretation of the results of a postmortem tissue analysis for carbon monoxide is essential to the Flight Surgeon investigating major aircraft accidents. The pitfalls and shortcomings of the present technique of extra-polating presumed human in vivo blood carbon monoxide levels from data obtained by rat experimentation are described. Data are presented which indicate the necessity for relating carbon monoxide tissue analyses to the tissue blood content. - Authors' Abst.

414. Trinkina, I.A.: The time of the carbon monoxide excretion from the organism of the poisoned subject and the possibility of its post-mortem entry into the blood. Abst. Soviet Medicine Part B. Clinical Med. 4:985-986, 1960.

Twenty rabbits were exposed in a hermetically-sealed chamber to carbon monoxide fumes at a concentration of 0.15-0.20% for 15-20 minutes. Blood carbon monoxide levels were determined using Van Slyke's technique before and 15 minutes, 20 minutes, 3 hours, and 6 hours after removal of the animals from the chamber. In addition, 21 cadavers were exposed to various concentrations of CO in the sealed chamber. Subsequently, aqueous extracts of lungs, brains, and ecchymoses, as well as cardiac and vascular blood, were examined with the help of spectroscopic analysis, tannin tests, etc. No CO could be demonstrated in the blood of the animals 9-11 hours after exposure. In the case of cadavers, injured or noninjured, no carboxyhemoglobin could be demonstrated whatever the duration of exposure and whatever the time interval between death and the start of the experiment. - APCA 4109

415. Wilks, S.S., and Clark, R.T., Jr.: Carbon monoxide determinations in post-mortem tissues as an aid in determining physiologic status prior to death. J. Appl. Physiol. 14:313-320, 1959.

With appropriate methodology, carbon monoxide in the 'solid' tissues of animals was quantitated and correlated with the blood carbon monoxide level in a series of controlled experiments with rats and dogs. Experimental conditions simulating aircraft crashes were devised and again the blood and 'solid' tissue CO levels were determined.

Using the experimental data on animals as a basis for extrapolating blood CO levels, along with tissue CO values, obtained from 'control' and CO-asphyxial cases in human beings, an analysis was made of the 'solid' tissue specimens obtained in 186 fatal aircraft accidents. From the analysis of tissue specimens from approximately 200 aircraft crash cases, some 30% gave by this method a blood CO level in excess of 30% saturation. These results point to the likelihood that CO was present in the personnel compartments of some or all of these aircraft at some time during flight. - Authors' Abst.

Smoking

416. Bokhoven, C., and Niessen, H.J.: Amounts of oxides of nitrogen and carbon monoxide in cigarette smoke, with and without inhalation. Nature 192:458-459 (Nov. 4) 1961.

This paper describes investigations to determine concentrations of NO_s and CO in cigarette smoke, with and without inhalation. As a result of inhalation both the NO_s and the CO are absorbed to a large extent. The amount of these compounds which may be taken up by the body were estimated. If 20 cigarettes a day are smoked, 3.0 mgm of NO_s (calculated as NO_2) and 200 mgm of CO may be absorbed. These figures are considerably higher than the amounts namely 12 X 0.1 = 1.2 mgm NO_s and 12 X 2 = 24 mgm of CO, regarded as the maximum which can be safely tolerated. Author points out that for evaluation of health effects of smoking, the possibility of synergism, caused by the simultaneous presence of both NO_x and CO should also be taken into consideration. - AGC

417. Chinn, H.I.: The Effect of Smoking at Simulated Altitudes on Carboxyhemoglobin Formation. School of Aviation Medicine, Randolph AFB, Texas, Feb. 29, 1944, 3 pp. DDC AD 121 707.

The carboxyhemoglobin concentration of blood in regular smokers (10 to 30 cigarettes daily) averaged 2.2 per cent of the total hemoglobin.

After smoking 4 cigarettes in 30 minutes, the concentration of carboxyhemoglobin rose to 3.9 per cent.

There was no significant difference between the carboxyhemoglobin concentration after smoking at ground levels or at simulated altitudes of 12,000 or 15,000 feet.

The increased carboxyhemoglobin after smoking is of little significance at ground levels but becomes increasingly important at altitudes above 10,000 feet. - Author's Abst.

418. Curphey, T.J., Hood, L.P.L., and Perkins, N.M.: Carboxyhemoglobin in relation to air pollution and smoking. Arch. Environ. Health 10:179-185 (Feb.) 1965.

A total of 1,075 coroners' cases, for each of which a carbon monoxide blood concentration determination has been made, were classified as to smoking habits to ascertain what, if any, association existed between the carbon monoxide content in the ambient air, smoking history, and carboxyhemoglobin levels found in cadaver blood. Persons classified as nonsmokers were presumed to have been exposed in the last 24 hours of life only to atmospheric carbon monoxide.

Analysis of the data reveals that nonsmokers consistently had lower carbon monoxide values than smokers. In the one instance where analysis was possible on the basis of sex, the median value for male nonsmokers was greater by a factor of two, than for female nonsmokers. Graphically and by statistical analysis, the variables of age, location of examination, time of day, and day in week of death, maximum-minimum temperatures, or causes of death revealed little or no individual effect on carboxyhemoglobin levels. This was true for nonsmokers as well as for smokers. Smoking remained constant as the major variable associated with observed differences. When analysis was made to determine what association if any among nonsmokers existed between carboxyhemoglobin levels and ambient air carbon monoxide content, the association was significant ($p < 0.05$). This significant association was not noted for every location.

This study points out the potentialities of utilizing populations and other facilities of the chief medical examiner-coroner's office in furthering explorations in the field of air pollution research in general and the effects of carbon monoxide in particular. - Authors' Sum.

419. De Bruin, A., Vroege, D., and Van Haeringen, A.: Study of carbon monoxide uptake in traffic policemen. T. Soc. Geneesk. 43:146-151 (March 5) 1965.

The HbCO-content of the blood of 36 municipal traffic policemen--non-smokers--in Rotterdam exposed to exhaust from motor vehicles, during one to four hours, has been measured. The data were compared to those of a control group of 16 non-smoking policemen working in the office. Blood samples have been taken before and after work. The HbCO-content was on the average 0.93% before work and increased to 1.11% in the exposed group, whereas the HbCO-content in the control group remained about the same. The peak CO-content in the air was between 5-15 ppm. The chemical analysis has been performed with two independent methods. - APCA 65-154

420. Dunlap, R.: Carbon monoxide the silent killer. Today's Health (Nov.) 1961, pp. 26-27, 67-68, and 71-72.

Every year motor vehicles pour out 169,600,000,000 pounds of CO into the air of American cities. The share of each urban dweller amounts to some 30 pounds of the deadly gas every 24 hrs. By 1970 an expected 100 million vehicles will be traveling some trillion miles a year and the possible environmental danger from CO will have to be controlled. CO has a remarkable affinity for red blood cells. It is absorbed by them 250 times as fast as oxygen. The gas unites with the hemoglobin and keeps it from carrying oxygen to the tissues. This means that even a seemingly inconsequential .02 percent CO can be lethal. Tobacco smoking also increases the level of CO in the blood. Police files show that every year 600 lives are lost due to carbon monoxide in the United States. It is also assumed that this colorless, tasteless, nonirritating, and odorless poison gas is a contributing factor to a high percentage of approximately 180,000 highway accidents caused annually by drivers who black out or fall asleep at the wheel. Concern is expressed about the level of CO poisoning that may be encountered by a motorist smoking a cigarette. Studies conducted by the U.S. Public Health Service's Division of Air Pollution and such by other authorities are discussed to alert the public to the danger of carbon monoxide. -AGC

421. Goldsmith, J.R., and Rogers, L.H.: Health hazards of automobile exhaust. Pub. Health Rep. 74:551-558 (June) 1959.

In Los Angeles, the air pollution from diesel engine exhaust is about 20 tons of organic emissions/day while that from automobile exhausts contributes about 1200 tons/day. Because the theoretical value (15:1) for air to fuel required for complete combustion is seldom maintained in automobiles, their exhausts frequently contain carbon monoxide, hydrogen, aldehydes, unburned hydrocarbons, sulfur oxides, and some lead compounds depending on the additives used. The constituents (in % of concentration, vol./vol.) of automobile exhausts are listed in table 1. Of these only carbon monoxide nitrogen oxides, lead compounds, and hydrocarbons are discussed in this paper. The max. CO concentration in Los Angeles, reported in table 2, is 93.2 ppm., with an average value of 15 to 36 ppm. British cities have reported an average of 4 to 20 ppm. with a max of 80 ppm. during smog. In Detroit, during heavy traffic an average of 28.9 ppm., with 80 ppm. max., has been reported. Although no health damage has been attributed to levels of CO below 100 ppm. there is undoubtedly some inactivation of hemoglobin. The level of CO saturation in the blood is greatly increased in tobacco smokers. Although experimental studies have shown an impaired adaptability of the eyes to darkness when young subjects were exposed to low levels of CO, this has not been shown by exposure to automobile exhausts at the levels found on city free-ways. It is, however, a plausible inference. The toxicity of nitrogen dioxide is based on its irritant properties, especially to the pulmonary membranes in cases of significant exposure, which are often delayed in onset. The nitrite ions formed when nitrogen dioxide dissolves are capable of forming the inactivated hemoglobin known as methemoglobin. Lead exposure by air pollution alone as reported by Los Angeles and other cities is usually not toxic but the small persistent amounts which could be contributed by auto exhausts may contribute to cases of toxicity in certain individuals working in garages and other work areas. Hygienic standards have been established for industrial exposure to CO, nitrogen dioxide, lead, and ozone. Establishing a full set of levels for community exposure is difficult because of the many variables involved, including the effect of agents in combination, the difference in sensitivity of ill persons, and the indeterminate period of exposure. The authors suggest that, in the absence of effective control for air pollution from automobile exhausts, the public health hazard should be evaluated. - APCA 2647

422. Goldsmith, J.R., Terzaghi, J., and Hackney, J.D.: Evaluation of fluctuating carbon monoxide exposures. Arch of Environ. Health 7:647-663 (Dec.) 1963.

The patterns of population exposure must include exposure of cigarette smokers, of those subjected to community air pollution, those with exposures to motor vehicle exhaust during commuting, and those with occupational exposure to carbon monoxide. Combinations of these exposures were reduced to 6 typical daily routines which approximated the exposures usually encountered by the population. Estimated exposure of automobile commuter is about 35 ppm, twice normal downtown peak, for duration of trip. Estimated exposure of cigarette smoker is 475 ppm for 6 minutes smoking time per cigarette. - LEPS

423. Gunderman, K.O.: Hazards of the motorist by carbon monoxide. Stödtehygiene. 77:248-253, 1964.

The results of CO recording in the two large cities Kiel and Hamburg in Northern Germany, during rush hours show clearly that they are above the harmless limits of the industrial MAC of 0.01 Vol. %. These values which present the maximal limits at the present time in both cities, will most probably not be increased because of the relatively favorable climate of these cities. However, under climatic unfavorable condition the same traffic density may cause dangerous CO levels. The recorded CO concentrations may become, however, a severe threat to the health of the population in these two cities mentioned above, if traffic and with it the exhaust emission are being increased to the level as it prevails at present only a few hours during the day, for a considerable longer period of time. Additional danger to the motorist is caused by heavy smoking. It is strongly recommended to reduce exhaust gas emissions. It is also requested to keep traffic moving by enlarging roads, by planting greeneries on traffic islands, and through improvement of engine design. Of importance is also the construction along the roads which should not impede ventilation. These measures would also reduce the danger cause by other exhaust components, for example carcenogenic propertie However, chronic effects of long-term inhalation of various auto exhaust pollutants needs to be investigated further. Translation of sum. -AGC.

424. **Hackney, J.D., Lashier, H., Lynn, K., and Spier, C.: Comparative effect of two sources of exposure to carbon monoxide on carbon monoxide hemoglobin levels. Presented at the Air Pollution Research Conference on "Effects of Motor Vehicle Emissions on Health," Dec. 6, 1961, Los Angeles, Calif.**

The comparative effect of two sources of carbon monoxide exposure, e.g., ambient CO and ambient CO plus cigarette smoke on the COHb of two normal subjects working as a team is discussed in this study. The rebreathing method for indirect estimation of COHb as previously described (1) was used in this study for the frequent monitoring of COHb. Samples of the ambient air were collected almost continuously during the experimental run as a means of representing the integrated total ambient CO exposure. - Authors' Introduction

425. Haddon, W., Jr., Nesbitt, R.E.L., and Garcia, R.: Smoking and pregnancy: Carbon monoxide in blood during gestation and at term. Obstet. Gynec. 18:262-267 (Sept.) 1961.

Blood carbon monoxide (CO) concentrations in women seen in a prenatal clinic were significantly higher in smokers than in nonsmokers. Carbon monoxide concentrations in paired cord and maternal blood specimens obtained at term were found to be approximately equal, whereas CO concentrations per 100 gm. of hemoglobin were lower in cord than in paired maternal blood specimens. The differences between smokers and nonsmokers in the reduction in O_2-carrying capacity in the cord and maternal blood specimens, respectively, were also statistically significant. These reductions in maternal and fetal oxygen-carrying capacity and the action of CO as an enzyme inhibitor are discussed from the standpoint of their possible effects on fetal development. - Author's summary

426. Hanson, H.B., and Hastings, A.B.: The effect of smoking on the carbon monoxide content of blood. J. A.M.A. 100:1481 (May 13) 1933.

In a short series of normal individuals who do not smoke, the hemoglobin of the blood was found to be saturated with carbon monoxide, 1.5 per cent.

In subjects who smoke the saturation of the blood with carbon monoxide was found to be from 3 to 4 per cent. - Authors' Conclusions

427. Heron, H.J.: The effects of smoking during pregnancy: A review with a preview. New Zealand Med. J. 61:545-548 (Nov.) 1962.

Carbon monoxide blood concentrations were found to be higher in maternal and foetal bloods in patients who smoked.

Respiration in infants of mothers who smoked took longer to establish and peripheral cyanosis was more common.

The condition of such infants appeared to revert to more nearly normal when they were placed in a high oxygen concentration for a short time. - Author's Sum.

428. Jones, G.W., Yant, W.P., and Berger, L.B.: Carbon-Monoxide Hazards from Tobacco Smoke. USBM, No. 2539 (Oct.) 1923, 6 pp.

The Bureau of Mines is interested in the general question of carbon-monoxide hazards from tobacco smoke, mainly with regard to mine ventilation. In non-gaseous mines, especially metal mines, the question arises, whether, if groups of miners are permitted to smoke while working at unventilated faces or entries, would the accumulation of tobacco smoke in these places create any additional hazards due to carbon-monoxide poisoning. The results should, in addition, be of general interest in connection with ventilation of building and inclosed places where people may be assembled and smoking is permitted. The investigation described in this report was made with the above idea in view. - From Text-AGC

429. McFarland, R.A. and Moore, R.C.: Human factors in highway safety. A Review and Evaluation. New England J. Med. 256:890-897 (May 9) 1957.

This article is the last of a series of three papers appearing in previous issues dealing with the same subject. The interrelationship between "lost" and "environmental" factors are the last subject discussed.

Author states that the possibility of CO poisoning can rarely be completely eliminated in the operation of motor vehicles. Although significant concentration of CO in motor vehicles usually is the result from leaks in the exhaust system, gas from the exhaust of preceding vehicles may also be drawn in through ventilation systems. The paper points out that exposure to 0.10 percent CO can be dangerous to life after one hour. Exposure to even as small a concentration as 0.01 percent should not be permitted over a long period. CO from other sources may be detrimental to the driver. The blood of a person who has been smoking heavily may already contain 5 to 8 percent carboxyhemoglobin from the CO inhaled in the tobacco smoke. This amount results in sufficient anoxia to reduce night vision significantly, comparable to the effects of high altitude of about 800 feet.

This factor is illustrated by a graph. In conclusion , author states that the physician, in collaboration with other biologic scientists and engineers, will play an important part in the prevention of accidental trauma. -AGC.

430. McFarland, R.A., and Moseley, A.L.: Carbon monoxide in trucks and buses and information from other areas of research on carbon monoxide, altitude and cigarette smoking. Conf. Proc.: Health, Medical and Drug Factors in Highway Safety, April 1964, Wash., D.C., Nat. Acad. Sc. - Nat. Res. Council Pub. 328, Sept. 1964, pp. 4.17-4.33.

Data were presented concerning the frequency and severity of carbon monoxide accidents in passenger and cargo operation in interstate commerce. Approximately 1.3 percent of mechanical defects accidents from 1947-1951 are known to be due to carbon monoxide. Fatalities and property damage accidents were higher for property carrying vehicles than for passenger carrying vehicles while injuries were higher in the latter. Fatalities occurred while vehicles were stopped, and injuries tended to occur while the vehicle was in motion. The fatality and injury rates are disproportionate in relation to the total of mechanical defects accidents.

Carbon monoxide sources within the vehicle are due primarily to engine exhaust and secondarily to combustion of lubricating oils and sources in other vehicles. Accessability to the cab is through the breather, manifold, head gaskets, muffler, tail pipe, air tank and air operated devices and their connections, fittings and exhausts. In some vehicles an extra source was found in methods of heating and of preventing engine freezing in cold weather.

Operational data in a closed idling test after 15 minutes disclosed 100 p.p.m. CO concentration in 10 truck models, no level in one, and 200 p.p.m. in one. In five of six buses the finding was less than 10 p.p.m. and in one was 100 p.p.m. Two units converted to bookmobiles gave 200 p.p.m. readings after 15 minutes of operation of a single gasoline heater. Using a highway test of 45 minutes of closed roadway operation, tests on 20 trucks and 60 buses yielded CO values of less than 10 p.p.m.

Clinical evidence of CO exposure was found in the personnel of the bookmobiles.

While gross studies of driving do not show losses due to CO until 30% arterial saturation is reached, studies of differential brightness threshold indicate that visual sensitivity and acuity under low illumination conditions are negatively influenced by anoxia and exposure to CO. The effects are progressive as the oxyhemoglobin decreases, and as carboxyhemoglobin increases. The effects are produced by smoking. Visual losses due to anoxia may be offset in part by increasing the level of blood sugar. - Authors' Sum.

431. Mantell, C.D.: Smoking in pregnancy: The role played by carbonic anhydrase. New Zealand Med. J. 63:601-603 (Sept.) 1964.

An outline of the method used to estimate the carbonic anhydrase content in a specimen of cord blood has been given. This method involved the absorption of CO_2 by a buffer solution so as to lower its pH to the end point of the indicator.

Results show a decrease in carbonic anhydrase activity in the cord bloods of infants whose mothers smoked.

Classification at birth, length of gestation, and birth weights of the infants were also affected.

The differences in enzyme activity, foetal birth weights and condition, and the prematurity rate between infants of light and heavy smokers and between those who smoked and those who did not smoke during labour, were insignificant. - Author's Sum.

432. Meigs, J.W.: Carbon monoxide poisoning. Bull. U.S. Army Dept. 8:542-546, 1948.

The danger of carbon monoxide poisoning among men working on gasoline-driven vehicles is emphasized. A concentration of several thousand parts per million may occur in the air near the exhaust outlet, even outdoors, unless exhaust gases are discharged so that the carbon monoxide is diluted before it can return to any area where it may be inhaled. Symptoms, which usually occur when the carboxy-haemoglobin content of the blood reaches 20 percent, include headache, dizziness, faintness, nausea, and vomiting. Samples of oxalated blood should be analyzed for the presence of carbon monoxide as soon as possible after exposure, to minimize reoxygenation of carboxy-haemoglobin, but they can be frozen and sent to a laboratory. The presence of a significant amount of carbon monoxide in the blood will differentiate symptoms due to carbon monoxide poisoning from those due to other causes, especially alcohol. Heavy cigarette smoking may produce carboxy-haemoglobin levels up to 10 percent.- BMB 402

433. Mills, C.A., and Porter, M.M.: Tobacco smoking and automobile-driving stress in relation to deaths from cardiac and vascular causes. Amer. J. Med. Sc. 234:35-43 (July) 1957.

A direct association well beyond the realm of reasonable chance occurrence has been found to exist between cardiovascular disease death rates in white men and the amount of cigarette smoking in which they habitually indulge. Superimposed upon all categories of this cigarette smoking relationship is a further sharp death-rate rise associated with annual driving mileages above 12,000 miles, and still further superimposition in all categories is associated with residence in the solidly built-up basin areas of the city (Cincinnati).

These relationships are essentially analogous to those we found to exist for lung cancer death rates in white men, although the apparent exacerbating relationship was much greater between smoking and lung cancer deaths than between smoking and cardiovascular disease deaths. - Authors' Sum.

434. Mills, C.A., and Porter, M.M.: Tobacco smoking, motor exhaust fumes, and general air pollution in relation to lung cancer incidence. Cancer Res. 17:981-990 (Nov.) 1957.

Details are presented of a survey covering residence, smoking and driving habits of living populations and those dying of lung cancer in the basin and suburban areas of Cincinnati and in Ohio rural areas. The findings in this survey give rise to the following deductions and conclusions:

Tobacco smoking was found to be significantly related to lung cancer incidence in the subjects of this study, whether or not there was in addition heavy exposure in urban motor traffic or to general urban air pollution.

Annual driving mileages above 12,000 miles per year, as compared with lesser driving mileages, are significantly related to lung cancer incidence among urban men, except for those in the heavy smoking category.

Lung cancer death frequencies were found significantly higher among Cincinnati's Basin men than among suburban men in this survey.

Lung cancer rates in nonsmoking men, urban or rural, did not differ significantly from the low rates found prevailing in women of all groups.

Finally, it is suggested that the alarming rise in lung cancer incidence is predominantly a hazard pertaining to urban tobacco smoking, but a hazard intensified for those urban smokers with heavy exposure also in urban traffic. - Authors' Sum.

435. Nichols, G., Jr., and Kinsey, J.L.: Carbon monoxide as a habitability factor in prolonged submarine submergence. U.S. Naval Medical Research Laboratory, New London, Conn., Report No. 223, (April 16) 1953.

Toxic conc. of CO accumulate when there is unrestricted smoking in sealed spaces, such as a submarine during a prolonged submergence. 23 volunteers on Operation Hideout were exposed to CO levels of approx. 100 or more ppm for continuous period of 6 days, following a period of 12 days' exposure to CO conc. between 50 and 100 ppm and period of unknown length during which this conc. accumulated; 6 day period was followed by 4 days of exposure to CO conc. varying from 25 to 100 ppm. Comparing 6 day period of exposure to 100 ppm with 6 day period immediately following return to outboard ventilation, subjective complaints as ms. by number of headaches were significant at 10% level. Significant amts. of hb were saturated with CO; in only 2 cases, however, was this considered to be in range where subjective complaints occur, and in each of these 2 there were no symptoms. CO-blood saturation dropped rapidly (1 day) upon return to outboard ventilation. - Kett.

436. Ringold, A., Goldsmith, J.R., Helwig, H.L., Finn, R., and Schiette, F.: Estimating recent carbon monoxide exposures. A rapid method. Arch. Environ. Health 5:308-318 (Oct.) 1962.

A valid method for determining the carboxyhemoglobin level in the body has been developed. The method is based on the 20-second breath-holding method first described by Jones et al., using an infrared analyser first reported by Lawther and Apthrop. Our work shows that a polyvinyl bag can be used for collection of samples in the field.

An application of this method is reported. This confirms the fact that cigarette smoking is a major factor in determining the carboxyhemoglobin level in a population. Pipe and cigar smokers appear not to have much increase in carboxyhemoglobin.

The method should be suitable for studying the relationship of carboxyhemoglobin to occupational and to ambient air pollution exposures. - Authors' Sum. & APCA 5047

437. Sievers, R.F., Edwards, T.I., and Murray, A.L.: A Medical Study of Men Exposed to Measured Amounts of Carbon Monoxide in the Holland Tunnel for 13 Years. Federal Security Agency, U.S. PHSB No. 278, 1942, Washington, D. C., 74 pp, and J. AMA 118:585-588 (Feb.21) 1942

Medical examinations of 156 traffic officers on duty at the Holland Tunnel for 13 years and four months were made as a practical test of the effectiveness of the medical and engineering control methods set up for their protection. About half of these officers had been on tunnel duty every working day of this period. Average carbon monoxide exposure throughout the tunnel for all hours of the day was approximately 70 ppm. Results of medical examinations of men on duty for the first five years showed them to be in excellent physical conditions. No evidence of symptoms attributable to carbon monoxide intoxication and for sequelae of acute episodes was found. The effects of both smoking habits and of occupational exposure to carbon monoxide concentrations in blood samples were analyzed by the Van Slyke method. The lowest concentration value, expressed as percent of hemoglobin combined with carbon monoxide, was 0.5; the highest value was found in a tunnel officer, a heavy smoker, coming directly from unusually heavy atmospheric exposure, was 13.1. No signs or symptoms attributable to carbon monoxide were observed within this range. Concentrations of carbon monoxide in the blood of toll collectors on the holiday selected for observation ranged up to 15.1 percent, expressed as percent of hemoglobin combined with carbon monoxide.

Authors do not feel that there is reason to assume that prolonged exposure to these concentration levels will result in injury to health. Precautions in force in the Holland Tunnel set up for the elimination of the possibility of acute exposure is to be extended in order to protect the health of all persons unavoidably exposed to carbon monoxide. - Authors' Abst. Modified-AGC

Tissue Chemistry

438. Campbell, J.A.: Tissue oxygen tension and carbon monoxide poisoning. J. Physiol. 68:81-96, 1929-1930.

During the first few days of carbon monoxide poisoning the tissue oxygen tensions are lowered to a more marked degree than by a similar loss of function of haemoglobin due to bleeding of haemolysis; this agrees with J.S. Haldane's prediction. A similar, but not so marked, difference applies to the carbon dioxide tensions in the tissues.

It is possible for animals (rabbits, rats, mice, guinea-pigs) to tolerate about ·250 p.c. of carbon monoxide in the air for several days after some degree of acclimatization, whereas ·150 p.c. of the gas is not tolerated for three days by unacclimatized animals.

Even when an animal is exposed to gradually increasing percentage of carbon monoxide, the tissue oxygen tensions are abnormally low, although there is increased breathing and also great increase in the haemoglobin content per cubic millimetre of blood. At the same time the tissues show marked histological evidence of disintegration, extreme congestion of the liver with atrophy of liver cells being the outstanding feature, for which heart failure is held mainly responsible. Power to tolerate carbon monoxide depends upon the powers of the vital organs, particularly the heart, to continue to function under a low tissue oxygen tension.

The resemblance between the effects (physiological and pathological) of carbon monoxide poisoning and of exposure to low oxygen pressure in the air is striking.

The carbon monoxide tension in the tissues has been measured; usually it is about one-third of that in the inspired air. The low carbon monoxide tension in the tissues is due to the very low oxygen tension (1-3 p.c.) which exists in the tissues, the reduced blood in the capillaries carrying the carbon monoxide back again to the lungs. - Author's Sum.

439. Campbell, J.A.: The effect of carbon monoxide and other agents upon the rate of tumour growth. J. Pathol. & Bacteriol. 35:379-394, 1932.

It is shown that breathing carbon monoxide (up to 0.28 per cent) for prolonged periods has a marked retarding effect upon the rate of growth of mouse carcinoma 63 and increases duration of active life after inoculation. No such effect was observed with the Rous fowl sarcoma.

Some experiments with Fischer-Wasels' gas therapy and others with the "growth-retarding hormone" gave no evidence of inhibitory effects upon Rous fowl sarcoma and mouse carcinoma 63. - Author's Sum.

440. Campbell, J.A.: Growth, fertility, etc. in animals during attempted acclimatization to carbon monoxide. Quart. J. Exper. Physiol. 24: 271-281, 1935.

Some mice and rabbits maintain their rate of growth when slowly acclimatized to about 0.3 per cent. of carbon monoxide in the inspired air. It is pointed out that man's ability to acclimatize gradually to the gas has never been properly tested, and, although not so resistant as certain animals appear to be, he probably possesses much greater resistance, to such gradual exposure, than has so far been suspected.

The heart of the mouse is often much hypertrophied during slow acclimatization, and this organ is regarded as playing a chief part in the powers to acclimatize.

The mouse appears to be more easily acclimatized to carbon monoxide than to low oxygen pressure in the air.

Mice after acclimatization to 0.30 per cent. carbon monoxide are not fertile; true acclimatization is thus not attained.

If carbon monoxide is consumed by living animals when breathing 0.30 per cent. of the gas, the consumption must be of a very low order, as is to be expected from Fenn and Cobb's results for frog's skeletal muscle exposed in vitro to 80 per cent. of the gas.

The carbon monoxide pressure in the tissues is less than half that in the inspired air. Oxygen pressures in the tissues are reduced to half the normal value in an acclimatized animal breathing 0.30 per cent. carbon monoxide. - Author's Sum.

441. Ellis, J.P., Clark, R.T., Jr., Wilks, S.S., and Criscuolo, D.: Carbon Monoxide Capacity Measurements on Human and Rat Skeletal Muscle. School of Aerospace Med., Brooks AFB, Texas, Oct. 1959, pp. 6. DDC AD 231541.

Two methods were comparatively evaluated for subsequent use as a measure of the CO capacity of animal tissues. One method was based on measurement of the volume of carbon monoxide extracted from muscle homogenates which had previously been equilibrated with known CO-N_2 mixtures; the other method was based on estimation of the CO capacity from the spectrophotometric differential determination of the hemoglobin and myoglobin content of the muscle. Use of the equilibration technic resulted in lower and more erratic values than those indicated by the spectrophotometric analysis. The fact that the spectrophotometric analysis also permitted simultaneous estimation of the tissue blood content served to discourage further attempts to develop a more reproducible equilibration system.

A comparative analysis, employing the two methods, was also carried out on human and rat muscle. Although results from the equilibration analysis were low, both methods indicated that the CO capacity of human tissue was three times greater than that of rat tissue. An examination of the hemoglobin-myoglobin relationship in the two species revealed that the greater capacity of human tissue was due to a proportionate increase in the concentration of both pigments. - Authors' Sum.

442. Fenn, W.O., and Cobb, D.M.: The stimulation of muscle respiration by carbon monoxide. Amer. J. Physiol. 102:379-392, 1932.

Substituting carbon monoxide for the nitrogen of the air surrounding a frog sartorius muscle increases the respiration usually 1.5 to 3 times.

A similar though smaller increase in metabolism is produced in the same way in muscle mash of frogs and rats, in frog muscles which are spontaneously non-irritable or non-irritable from isotonic KCl.

The increase is diminished but not abolished by loss of the irritability of the muscle; it persists when the formation of lactic acid is inhibited by sodium bromacetate treatment; it cannot be correlated with any changes in irritability or contractility of the muscle.

Both the normal respiration and the excess respiration due to CO are diminished to approximately the same extent by KCN, isotonic $CaCl_2$ and by loss of soluble material from the tissue by diffusion or water extraction.

Light has no significant effect upon the excess respiration due to CO.

The anaerobic acid-base changes of muscle, as followed by the CO_2 absorption or elimination in CO_2 atmospheres were not affected by the presence of CO in place of H or N. CO does not therefore affect significantly the formation of lactic acid or the breakdown of phosphocreatine although a slight increased anaerobic lactic acid content was found in gastroenemius muscles in CO.

The tension developed in single shocks for a given amount of initial heat was not affected by CO.

The R.Q. of muscles was lowered from 0.87 to 0.76 by CO. This suggested a burning of CO to CO_2.

443. Gilinskiy, V.A., Chapek, A.V., Kozlova, A.G., Kulikova, N.M., and A. Ya. Loshak: The effect of low concentrations of carbon monoxide on man in pressurized cabins of passenger planes. In: Parin, V.V. (editor) Aviation and Space Medicine, Moscow, 1963. NASA Technical Translation TT-F-228.

Pressure-chamber experiments were performed on 82 persons to study the effect of low concentrations of carbon monoxide. Also, 30 flights on IL-18, AN-10, and TU-104 planes were made during which 185 members of the crew and passengers were examined and 347 air samples were obtained in the cabins. The results of the investigations showed that 3 hours' exposure to carbon monoxide (starting with 0.01 mg/liter or more), both under experimental conditions (ground and pressure-chamber at 2400 m) and during actual flight had adverse effects on the functioning of several organs and systems, namely: (a) Higher nervous activity; (b) Functions of the visual and vestibular analyzers; (c) Metabolic processes; (d) Cardio-vascular system; (e) Muscular strength; (f) Tissue respiration and; (g) Leukopoiesis. On the basis of the physiological-sanitary data obtained and the results of laboratory tests, it is suggested that the maximum permissible concentration of carbon monoxide in pressurized passenger airplane cabins be 0.01 mg/liter. - Authors' Abst.

444. Glantz, W.M., Stembridge, V.A., Dominguez, A.M., et al: Carbon monoxide determination in aircraft accident fatalities. Aerospace Med. 30:711-715 (Oct.) 1959.

Investigators at the Armed Forces Institute of Pathology have studied 747 cases of aircraft accident fatalities for the presence of carbon monoxide in postmortem tissues. All aircraft accident victims with carboxyhemoglobin elevation above 10 per cent were shown to have been alive at the time of the fire. Carboxyhemoglobin levels between 6 and 9 per cent saturation indicate the possibility that the subject was alive at the time of exposure to fire. Extensive fragmentation and postmortem incineration of tissues subsequent to explosive impact forces do not elevate the carboxyhemoglobin saturations. These investigators found no cases in which carbon monoxide intoxication has been implicated as the cause of an aircraft accident. Authors' Sum.

445. Haggard, H.W.: Studies in carbon monoxide asphyxia. II. The growth of neuroblast in the presence of carbon monoxide. Amer. J. Physiol. 60:244-249, 1922.

A technique is described whereby the growth of in vitro cultures of nervous tissue from the chick may be tested in any desired atmosphere or mixture of gases.

Carbon monoxide even in concentrations of 79 per cent is found to have no ill effect upon growing nerve cells. In this respect this gas is as neutral as nitrogen.

Illuminating gas has been studied in like manner and found to be toxic for neuroblast cultures in concentration of even as little as 0.1 per cent.

These observations indicate that carbon monoxide has no specific reaction with nerve tissue but acts in the body only through the asphyxia incident to its combination with hemoglobin.

These experiments indicate, also, that illuminating gas contains another toxic substance or substances; but this observation is not to be interpreted as weighing against the fact, well demonstrated, that asphyxia from inhalation of illuminating gas is chiefly due to carbon monoxide. - Author's Sum.

446. Haldane, J.B.S.: Carbon monoxide as a tissue poison. Biochem. J. 21:1068-1075, 1927.

The movements of a moth and the germination of cress seed are inhibited by CO. The greater the partial pressure of O_2, the more CO is required.

Rats living on O_2 dissolved in their blood in presence of sufficient CO to combine with almost all their haemoglobin are killed by the addition of more CO, which must affect some substance in their tissues.

It is concluded that cells contain a catalyst of oxidation which is poisoned by CO. Its affinity for CO is determined in the case of the moth. Its affinities differ in different species, and perhaps in different tissues. - Author's Sum.

447. Henderson, Y.: Carbon monoxid poisoning. J. AMA 67:580-583 (Aug. 19) 1916.

Carbon monoxid is a physiologically harmless gas, except in its affinity for hemoglobin. Its toxic effects are wholly due to the inability of the blood combined with carbon monoxid to transport oxygen to the tissues.

Carbon monoxid does not form a permanent compound with hemoglobin. In the presence of excess oxygen, or even of pure air, carbon monoxid is rapidly given off and the oxygen carrying power of the hemoglobin is restored.

The continuance of coma, the subsequent tissue degenerations, and death after several days, resulting from carbon monoxid poisoning, are not due to retention of the gas, but are the results of injury to the brain and other organs by the insufficiency of oxygen supplied to them by the blood while the patient was breathing the gas.

There is no reason to believe that either bleeding or transfusion of blood is beneficial. They are more likely to be harmful.

Fresh air--with oxygen inhalation for a short time as early as possible--symptomatic treatment, and good nursing are the only measures to be recommended. Practically the die is already cast for death, permanent defects, or complete recovery at the moment when the patient is brought out of the asphyxial atmosphere.

It is just possible theoretically that alkali therapy may be beneficial in combating the acidosis induced by asphyxia. - Author's Sum.

448. Howse, A.J.G., and Seddon, H.: Ischaemic contracture of muscle associated with carbon monoxide and barbiturate poisoning. British Med. J. 1:192-195 (Jan. 22) 1966.

Four cases of ischaemic muscle contracture associated with carbon monoxide or barbiturate poisoning are reported. It is probable that the condition is more common than the number of previously reported cases suggests.

Ischaemic nerve lesions occur, as in the more usual traumatic Volkmann's ischaemia.

The cause of this condition is almost certainly a combination of local pressure and general hypoxia. - Authors' Sum.

449. Ramsey, T.L., and Eilmann, H.J.: Carbon monoxide acute and chronic poisoning and experimental studies. J. Lab. & Clinical Med. 17: 415-427, 1931-1932.

Presented is a study of carbon monoxide from a standpoint of the method of its production, its affinity for hemoglobin, its action upon being respired, the percentages of blood saturation in varying lengths of time according to the concentration in the respired air, the symptoms and effect upon the body, possible methods of its elimination from the body, the production of chronic carbon monoxide poisoning, methods of treatment, the postmortem macroscopic appearances of the body following carbon monoxide deaths, some important medicolegal facts, a series of experiments on guinea pigs to ascertain its persistence in the body following exposure, and the histopathology of various tissues in animals dying, directly during exposure, and those killed and autopsied at varying periods later. - Authors' Sum.

450. Root, W.S., Allen, T.H., and Gregersen, M.I.: Simultaneous determinations in splenectomized dogs of cell volume with CO and P^{32} and plasma volume with T-1824. Amer. J. Physiol. 175:233-235, 1953. DDC-AD 34898.

Blood was removed from splenectomized dogs and separate portions were labeled with CO and P^{32}. The tagged cells were then injected into the same dog in order to measure the cell volume with the two methods simultaneously. At the same time plasma volume was measured with T-1824.

In 10 dogs the results show that the cell volume measured with CO is 12% greater than that measured with P^{32}-labeled cells, indicating that distribution of CO includes more than the circulating cell volume. The possibility is considered that the difference in the estimates of cell volume with CO and P^{32} may be a useful index of changes in erythropoietic tissue. - Authors' Sum.

451. Rounds, D. E., Awa, A., and Pomerat, C. M.: Effect of automobile exhaust on cell growth in vitro. Arch. Environ. Health 5:319-324 (Oct.) 1962.

The State of Calif. Dept. of Public Health has established in its standards for motor vehicle exhaust the reduction of hydrocarbon emissions by 80% and carbon monoxide emission by 60%. These standards specify that hydrocarbon concentrations are to be monitored by a hexane-sensitized nondispersive infrared analyzer or by an equivalent method. Conjunctival cells were exposed to an atmosphere of gaseous auto exhaust for varying periods of time, ranging from 15 sec. to 24 hrs. This treatment was observed to produce a decrease in the total mitotic index and an increase in abnormal mitotic figures. The tissue was also treated with varying dilutions of chloroform soluble constituents of auto exhaust with similar responses found in mitotic figures. Since mitotic events are interrelated with the rate of increase of the total cell population, it was concluded that an evaluation of the effect of auto exhaust on cell number can provide a simple, reproducible, and sensitive test system for estimating the relative concentrations of physiologically active components of automobile emissions. - APCA 4914

452. Schleusing, G.: Effect of hypoxia or anoxia on the mineral metabolism in the myocardium and skeletal muscles. Zeitschrift der Inneren Medizin 19:820-822 (Nov. 1) 1964.

By experiments of neutralization in vitro and by immunization of rabbits no substances corresponding with the antigens of human thrombocytes could be proved in Czechoslovak vaccines (dyphtheria, tetanus, whooping-cough, typhoid fever, paratyphoid fever, smallpox). AB-substances were only found in vaccines against typhoid fever and paratyphoid fever. - Author's Sum.

453. Schmitt, F.O., and Scott, M.G.: The effect of carbon monoxide on tissue respiration. Amer. J. Physiol. 107:85-93, 1934.

CO containing 21 per cent O_2 has little effect on the oxygen consumption of skin, nerve, kidney or intestine but produces definite accelerations with skeletal muscle, stomach, liver, spleen and particularly with heart muscle.

When the oxygen concentration is reduced to lower values, CO produces inhibition in all the tissues studied with the exception of liver, heart, and skeletal muscle.

Illumination causes partial, and in some cases complete recovery of respiration of the CO-poisoned tissues but has no effect on the control tissues in nitrogen containing a similar percentage of oxygen. There is some indication that the catalyst of CO combustion is also light sensitive.

With nerve and certain other tissues under favorable conditions the shape of the respiration curve during illumination is similar to that obtained following admission of oxygen after asphyxia, and is interpreted as representing the payment of the oxygen debt incurred during the period of partial inhibition. - Authors' Sum.

454. Stembridge, V.A., and Goldbaum, L.R.: The role of the Armed Forces Institute of Pathology in tissue toxicity study. Aviation Med. Symposium, Nov. 1957, pp. 5-8.

During the period from May 1957 through Oct. 1957, 269 determinations for CO have been accomplished at the Armed Forces Institute of Pathology utilizing a new method for obtaining a specimen. Of those 110 determinations for carbon monoxide on post-mortem tissues, 11 (10%) showed an elevation above 10 percent saturation. None of these 11 cases were considered a sudden death and in all there was evidence that the individual died primarily due to fire.

Post-mortem CO determinations are done in aircraft accident victims for two basic reasons: First, to determine whether carbon monoxide was present in the cockpit environment prior to impact (due to such factors as in-flight fires, exhaust fumes or improper venting of other combustion products) and second, to determine whether or not an individual was alive following an impact associated with fire. - From Text-AGC

Vision Impairment

455. Abt, I.A., and Witt, D.B.: A case of carbon monoxide poisoning in a child. Med. Clin. North America 5:1645-1651, 1922.

Acute carbon monoxide poisoning of a five year old boy who suffered total blindness, is described in this paper. The effect of CO poisoning on the blood and on various tissues and organs, particularly on the nervous structures, is discussed. Possibility of permanent blindness, assumed to be due to small hemorrhages or areas of softening in the visual centers, is outlined.

Authors review some of the hypotheses of other investigators in regard to the pathological changes produced by CO. Hemorrhages in the brain, degenerations, and optic thalmus, thrombosis, and areas of softening in the central nervous tissue and scattered small hemorrhages and intense hyperemia of all the body organs may occur as consequences to this type of poisoning. - AGC

455a. Adler, A.: Disintegration and restoration of optic recognition in visual agnosia. Arch. Neurol. Psychiat. 51:243-259, 1944.

A case of visual agnosia in a woman aged 22 has been described, the course of the illness having been followed from the first day until the condition became stationary. The patient is 1 of the 2 persons in whom permanent lesions of the brain were produced, probably by carbon monoxide fumes, in a fire disaster at a night club on Nov. 28, 1942.

The fundamental disturbance consists of the patient's inability to perceive the whole, the Gestalt, visually. Only parts of the whole are perceived, and their correct relation is not recognized. This results in an inability to read, to copy letters and geometric figures and to recognize pictures or objects on short exposure. Writing is unimpaired.

Owing to the patient's intelligence and insight into her disability, it was possible to identify an additional disturbance in the nature of a perserveration of visual attention and optic impressions. Preceeding optic impressions superimpose themselves on subsequent ones, so that proper perception and recognition are interferred with. This symptom is of the same category as psychomotor perseveration and perseveration of speech and writing.

According to Lissauer's first description, such a condition belongs to the "apperceptive" type of visual agnosia, since there is a primary disturbance of optic perception. In this patient the disturbance is clearcut to an unusual degree. The identity of the mechanism exhibited by this patient in each of the disorders of visual performance makes it unlikely that the various symptoms of optic agnosia have a separate localizing significance.

Compensatory efforts to build up new methods of visual recognition should be encouraged. Constant practice is necessary, since such a patient is likely to distort and to forget what he has learned. - Author's Sum.

456. Almgren, S.: Twelve years experience in the field of chronic carbon monoxide poisoning in Sweden. Arch. f. Gewerbepath. u. Gewerbehyg. 13:97-131, 1954.

In Sweden there was extremely high incidence of CO poisoning as a result of use of generator gas for automobiles and internal combustion engines in general. This gas contained 20-30% CO. Most of the workers in filling and cleaning of gas containers had more than 10% CO-hemoglobin and 29 of 30 fatal cases going to autopsy showed CO saturation.

Giddiness was shown on investigation by an otoneurologist to be associated in many cases with organic vestibular injury.

Other symptoms included ocular disorders (Disturbance of convergence and accommodation; diplopia; paresis of the eye muscles; and limitation of the field of vision); change of disposition with disorientation, absence of mind and poor judgement of distance leading to accidents. In reply to criticisms that these symptoms were colored by neurotic patients and that the ocular and aural symptoms were over-diagnosed, the author details five special cases.

457. Fejér, G.: Blindness caused by inhalation of coal gases, recovery. Amer. J. Ophthalmol. 7:522-523, 1924.

In the case here reported, disturbance of vision was noted on regaining consciousness, but it became worse, until two days later the patient was practically blind. Recovery was almost complete. The lesions seem to have been located in or near the cortical centers. - Author's Abst.

458. Fink, A.I.: Carbon-monoxide asphysia with visual sequelae. Amer. J. Ophthalmol. 34:1024-1027 (July) 1951.

The cerebral effects following carbon-monoxide asphyxia can be extremely varied.

Severe reductions in visual acuity following exposure to the gas are thought due to cortical blindness.

Alterations in the visual fields do not conform to any single pattern.

In many cases, perception for primary colors is present in spite of a severe reduction in visual acuity. This is unusual since centers for both reside in the occipital cortex. - Author's Sum.

459. Gilinskiy, V.A., Chapek, A.V., Kozlova, A.G., Kulikova, N.M., and A. Ya. Loshak: The effect of low concentrations of carbon monoxide on man in pressurized cabins of passenger planes. In: Parin, V.V. (editor) Aviation and Space Medicine, Moscow, 1963. NASA Technical Translation TT-F-228.

Pressure-chamber experiments were performed on 82 persons to study the effect of low concentrations of carbon monoxide. Also, 30 flights on IL-18, AN-10, and TU-104 planes were made during which 185 members of the crew and passengers were examined and 347 air samples were obtained in the cabins. The results of the investigations showed that 3 hours' exposure to carbon monoxide (starting with 0.01 mg/liter or more), both under experimental conditions (ground and pressure-chamber at 2400 m) and during actual flight had adverse effects on the functioning of several organs and systems, namely: (a) Higher nervous activity; (b) Functions of the visual and vestibular analyzers; (c) Metabolic processes; (d) Cardiovascular system; (e) Muscular strength; (f) Tissue respiration and; (g) Leukopoiesis. On the basis of the physiological-sanitary data obtained and the results of laboratory tests, it is suggested that the maximum permissible concentration of carbon monoxide in pressurized passenger airplane cabins be 0.01 mg/liter. - Authors' Abst.

460. Halperin, M.H., Niven, J.I., McFarland, R.A., and Roughton, F.J.W.: Variations in visual thresholds during carbon monoxide and hypoxic anoxia. Fed. Proc. (Abstract) 6:120-121, 1947.

The comparative and combined effects of carbon monoxide and hypoxic anoxia on human visual intensity discrimination, as well as the effects of normal and high O_2 atmospheres during recovery from CO, were investigated.

In previous studies we have found that the measurement of visual intensity discrimination thresholds at a low level of illumination provides a very sensitive, useful and precise quantitative index of the physiological disturbance caused by oxygen deprivation. We therefore applied the same technique in measuring the effects of small amounts of CO. Extensive studies were carried out on four well-trained subjects.

A given increase in % COHb in the blood at sea level produces an effect approximately equal to that of an equal decrease in % O_2Hb due to hypoxic anoxia. At simulated high altitudes, a given % COHb produces an impairment equivalent to a further ascent which would cause an equal additional decrease in % O_2Hb. The visual threshold is therefore much more sensitive to CO than are other physiological functions so far investigated.

In studying the recovery from CO, we found that the inhalation of oxygen, in addition to its value in accelerating the elimination of CO, had another beneficial effect as compared with the inhalation of ordinary air. An added improvement equivalent to a decrease of about 5 to 7% COHb was produced by breathing oxygen. When the subjects then breathed ordinary air, the thresholds were again impaired by this amount. If, instead of oxygen, the subject breathed ordinary air throughout the recovery period, the visual thresholds failed to recover as rapidly as the % COHb declined. - Authors' Abst.

461. Halperin, M.H., McFarland, R.A., Niven, J.I., and Roughton, F.J.W.: The time course of the effects of carbon monoxide on visual thresholds. J. Physiol. 146:583-593, 1959.

Visual sensitivity to differences in light intensity was employed as a sensitive index of (i) the effects of carbon monoxide, and of (ii) the persistence of these effects during elimination of this gas while ordinary air, oxygen and carbogen mixtures were breathed.

Recovery from detrimental effects of carbon monoxide on this visual function lags behind the elimination of carbon monoxide from the blood, the effect apparently being determined by the duration of the presence of carbon monoxide in the blood as well as its concentration.

Administration of 100% oxygen results in an immediate improvement which disappears when ordinary air is again breathed. This suggests the possible existence in the C.N.S. and/or peripheral visual system of some enzyme or other visually important constituent which combines competitively with carbon monoxide and oxygen.

Carbogen not only causes more rapid elimination of carbon monoxide from the body, but seems to have a somewhat more beneficial countering effect against carbon monoxide than does oxygen. - Authors' Sum.

462. Helminen, T.: On ophthalmological symptoms of chronic CO poisoning. Archiv für Gewerbehygiene 13:132-138, 1954.

The author describes a case of complete blindness caused by acute CO poisoning. The patient recovered within one month her normal visual capacity, however, a pecularity could be ascertained with the return of her color field vision. The author assumed it to be a symptom due to CO poisoning. After the 2nd World War, CO poisoning became the first major research project at the new clinic for occupational diseases. The findings were supported by the work of another scientist who ascertained extensive changes in the brain of a person who died of acute CO poisoning. Among others, he found necrotic lesions. Since it was assumed that repeated exposures to CO may cause changes in the organism, for example in the brain tissue, neurologic investigations were included in the research project. The author investigated 570 ophthalmological cases, under suspicion of CO poisoning, in course of which he made 1270 examinations of both sides of the field of vision. Which means that he examined each patient 2.5 times, in some cases a patient was examined more often. The results of the investigations showed: concentric shrinkage of the color field of vision. The author used blue, green, red and white objects. The blue and green fields of vision were more limited than the red field of vision. By severe poisoning all color fields of vision were inside 10° and also the white field showed clearly a concentric shrinkage. During reconvalescence the red field of vision enlarged faster, the blue and green fields slower. According to the author, in the case of doubt whether the patient is the victim of CO poisoning the concentric shrivelling of the color fields of vision is to be considered a symptom supporting the diagnosis. - From German-AGC

463. Johnson, D.M.: Killer on our highway. Good Housekeeping, June 1961, pp. 49 and 146-148.

This is a report of auto accidents fatal or near fatal possibly caused by the inhalation of CO. Author relates her own experience of CO asphyxiation, and describes the symptoms before she was overcome by CO fumes and crashed into another automobile. When she felt a strong sensation of drowsiness she wanted to pull off the road but was unable to see the side due to, as she found out later, the narrowing of the field of vision caused by the CO. In being overpowered by the drowsiness she lost judgement, control and consciousness, due to the fact that the inhaled lethal CO combines more than 200 times faster with the blood than oxygen. Thus the saturated blood cannot absorb enough life-giving oxygen. Deprived of oxygen the brain is affected sometimes severely and sometimes permanently. Author in quoting several case histories makes a plea for more research. Blood tests which are made routinely for the presence of alcohol, should be done just as routinely for the presence of CO in accident cases. Only the city of Philadelphia is doing these tests routinely when someone dies in a wreck. Philadelphia's medical examiner states that an appreciable percentage of drivers who die in automobile accidents have significant levels of CO in their blood. Author cautions driver to be aware that CO is odorless, to keep the car in good running condition and well ventilated - AGC

464. Kelly, R.G.C., and Hall, R.L.: A survey of the visual problems relating to motor accidents. In: Elliott, H. (editor): Medical Aspects of Traffic Accidents. Proc. Montreal Conf., May 1955. Traffic Accident Foundation for Medical Res., 1955, pp. 317-322.

One chapter of this book on traffic accidents deals with ocular manifestations of traffic accidents. And the following is excerpted from the survey of the visual problems relating to such accidents. The ability to see at night is cut down by alcohol, carbon monoxide, anoxia and smoking cigarrettes. Carbon monoxide may come from breaking gaskets, mufflers or tail pipes. McFarland found that 5% saturation with CO depresses visual sensitivity to as great an extent as anoxia at 8,000 to 10,000 feet altitude, while 15% saturation caused an impairment corresponding to that of 15,000 to 19,000 feet altitude. Other harmful effects of CO in addition to this visual effect are of course present.

465. Knapp, H.: A case of paresis of the eye muscle by carbon monoxide asphyxiation. Archive für Augenheilkunde 9:229-231, 1880.

Author describes a case of acute CO poisoning resulting in the paralysis of the eye muscles. The patient did not respond to various treatments, however, recovered partially after two months, leaving paresis of the sphincter of the pupil and the ciliary muscle. Available literature does not report cases of paralytic affection of eye muscles as a result of CO poisoning, but it does report on cases where other parts of the body have been afflicted by this type of poisoning. - From German-AGC

466. McFarland, R.A., Roughton, F.J.W., et al.: The effect of CO and altitude on visual thresholds. Aviation Med. 15:381-394, 1944.

The light sensitivity of the eye is adversely affected by very small amounts of CO, "measurable impairment being demonstrable with increments of about 3% carboxyhemoglobin." - PHS-RG 5676

467. McFarland, R.A., Dunlap, J.W., Hall, W.A., Moseley, A.L.: Human Factors in the Design of Highway Transport Equipment. A Summary Report of Vehicle Evaluation. Harvard School of Public Health, June 1953, pp. 44, figures and tables.

There is one small section on CO in this treatise (pp. 37-39). Concerning the adequacy of the cab in regard to overall safety. Tests were conducted on closed, moving cabs and on closed cabs (i.e. all doors, windows, and vents closed) after 15 minutes of standing with the engine idling. A table shows following results:

In %	In PPM 10,000	The Effect Is:
0.01%	1/100,000	No symptoms for 2 hours
0.04%	4/10,000	No symptoms for 1 hour
0.06-0.07%	6-7/10,000	Headache & unpleasant symptoms in 1 hour
0.10-0.12%	10-12/10,000	Dangerous after 1 hour
0.35%	35/10,000	Fatal in less than 1 hour

Authors state that prolonged periods of exposure to 0.01% should not be permitted, and warns that the inspiration of carbon monoxide does not have to produce serious toxic effects to become a source of hazard. Sensory losses, especially in vision occur at low carboxyhemoglobin levels, so that every reasonable control is essential. - AGC

468. McFarland, R.A.: Human factors in air transportation. McGraw-Hill, New York, 1953, pp. 301-303.

R.J. Goldsmith and L.H. Rogers are quoted to the effect that "The importance to automobile drivers of visual sensitivity at night is obvious. However, it has not been shown that exposure to automobile exhaust at the levels found on the freeways of a modern city impairs the adaptability of eyes to darkness or alters the exchange of vital respiratory gases, although this is a plausible inference." - PHS-RG 5676

469. McFarland, R.A., and Moseley, A.L.: Carbon monoxide in trucks and buses and information from other areas of research on carbon monoxide, altitude and cigarette smoking. Conf. Proc.: Health, Medical and Drug Factors in Highway Safety, April 1964, Wash., D.C., Nat. Acad. Sc. - Nat. Res. Council Pub. 328, Sept. 1964, pp. 4.17-4.33.

Data were presented concerning the frequency and severity of carbon monoxide accidents in passenger and cargo operation in interstate commerce. Approximately 1.3 percent of mechanical defects accidents from 1947-1951 are known to be due to carbon monoxide. Fatalities and property damage accidents were higher for property carrying vehicles than for passenger carrying vehicles while injuries were higher in the latter. Fatalities occurred while vehicles were stopped, and injuries tended to occur while the vehicle was in motion. The fatality and injury rates are disproportionate in relation to the total of mechanical defects accidents.

Carbon monoxide sources within the vehicle are due primarily to engine exhaust and secondarily to combustion of lubricating oils and sources in other vehicles. Accessability to the cab is through the breather, manifold, head gaskets, muffler, tail pipe, air tank and air operated devices and their connections, fittings and exhausts. In some vehicles an extra source was found in methods of heating and of preventing engine freezing in cold weather.

Operational data in a closed idling test after 15 minutes disclosed 100 p.p.m. CO concentration in 10 truck models, no level in one, and 200 p.p.m. in one. In five of six buses the finding was less than 10 p.p.m. and in one was 100 p.p.m. Two units converted to bookmobiles gave 200 p.p.m. readings after 15 minutes of operation of a single gasoline heater. Using a highway test of 45 minutes of closed roadway operation, tests on 20 trucks and 60 buses yielded CO values of less than 10 p.p.m.

Clinical evidence of CO exposure was found in the personnel of the bookmobiles.

While gross studies of driving do not show losses due to CO until 30% arterial saturation is reached, studies of differential brightness threshold indicate that visual sensitivity and acuity under low illumination conditions are negatively influenced by anoxia and exposure to CO. The effects are progressive as the oxyhemoglobin decreases, and as carboxyhemoglobin increases. The effects are produced by smoking. Visual losses due to anoxia may be offset in part by increasing the level of blood sugar. - Authors' Sum.

470. Wechsler, I.S.: Partial cortical blindness with preservation of color vision. Arch. Ophthalmol. 9:957-965, 1933.

This is a report of a case following possible CO asphyxiation, whereby the patient suffered a brain lesion in which the cortex was extensively affected. It has been established by clinical observation and pathologic studies that cortical and subcortical lesions may give rise to dissociation of color perception from visual acuity, namely, loss of former without impairment of the latter; it is also well known that in impairment of vision, whether peripheral or central, the first to be lost and the last to be regained is the perception of color.

Author points out that CO has a predilation for the basal ganglious, especially causing lenticular softening, and for the peripheral nerves, but no part of nervous system is immune to the poison. Parkinsonian syndromes and peripheral nerve palsies frequently characterize CO poisoning. Mental deterioration and psychotic manifestations so commonly encountered attest the additional cortical involment, as well as Parkinsonian syndromes and peripheral nerve palsies. - AGC

471. Wilmer, W.H.: Effects of carbon monoxid upon the eye. Amer. J. Ophthalmol. 4:73-89 (Feb.) 1921.

This paper gives a general survey of the subject and includes a graphic description of the subjective and general nutritional effects of carbon monoxid poisoning, by one of the victims; and incidentally throws light on the origin of a story of a haunted house. It gives an account of the ocular symptoms of such poisoning, revealing a distinct tendency of the poison to cause neuritis and especially to affect the optic nerve. - Author's Abst.

472. Xintaras, C., Ulrich, C.E., Sobecki, M.F., and Terrill, R.E.: Brain potentials studied by computer analysis. Arch. Environ. Health, in press.

The operation of an on-line digital computer that summates evoked low-amplitude brain responses to flashes of light in the implanted rat is described. The application of this technique in developing a "biological model" for inducing a reversible functional blindness in rats inhaling carbon monoxide is considered. The differential rate of recovery of specific components of the evoked response to carbon monoxide and pentobarbital are more easily resolved with this method. The use of the technique of the evoked response in parallel animal and human inhalation toxicity studies involving time-limited perceptual phenomena is suggested. - Authors' Abst.

BLOOD CHEMISTRY

Hemoglobin

473. Abramson, E. and Heyman, T.: Dark adaptation and inhalation of carbon monoxide. Acta Physiol. Scandinavia 7:303-305, 1944.

Inhalation of carbon monoxide, producing contents of carbon monoxide haemoglobin up to 30%, causes a diminution of dark adaptation, sometimes considerable sometimes smaller or none. It cannot be excluded that this condition may have practical significance for motorcar driving in the dark, e.g., in conjunction with dazzle when meeting. - Authors' Sum.

474. Almgren, S.: Twelve years experience in the field of chronic carbon monoxide poisoning in Sweden. Arch. f. Gewerbepath. u. Gewerbehyg. 13:97-131, 1954.

In Sweden there was extremely high incidence of CO poisoning as a result of use of generator gas for automobiles and internal combustion engines in general. This gas contained 20-30% CO. Most of the workers in filling and cleaning of gas containers had more than 10% CO-hemoglobin and 29 of 30 fatal cases going to autopsy showed CO saturation.

Giddiness was shown on investigation by an otoneurologist to be associated in many cases with organic vestibular injury.

Other symptoms included ocular disorders (Disturbance of convergence and accommodation; diplopia; paresis of the eye muscles; and limitation of the field of vision); change of disposition with disorientation, absence of mind and poor judgement of distance leading to accidents. In reply to criticisms that these symptoms were colored by neurotic patients and that the ocular and aural symptoms were over-diagnosed, the author details five special cases.

475. Arena, J.M.: Carbon Monoxide: Report from The Duke University Poison Control Center. North Carolina Med. J. 24:28-29 (Jan.) 1963.

This short paper summarizes the effect of CO poisoning on the health of man and advises on respective treatments. There is also a description of symptoms, in relation to percentage of CO in the atmosphere, duration of exposure and saturation of the blood. - AGC

476. Ayres, S.M., Giannelli, S., Jr., and Armstrong, R.G.: Carboxyhemoglobin: Hemodynamic and respiratory responses to small concentrations. Science 149:193-194 (July 9) 1965.

Hemodynamic and respiratory measurements were made on humans before and after inhalation of sufficient carbon monoxide to raise the carboxyhemoglobin to between 5% and 10% of saturation. Arterial and mixed-venous oxygen tensions decreased on average 7.3% and 13.3%, respectively. One of five subjects developed evidence of mild left-ventricular dysfuction. - Authors' Abst.

477. Barcroft, J., and Barcroft, H.: Observations on the taking up of carbon monoxide by the haemoglobin in the spleen. J. Physiol. 58: 138-144, 1923-1924.

When the haemoglobin of the spleen pulp, in rats breathing ·06-·1 p.c. CO, is compared with that of the general circulation, there is a lag between the percentage of CO haemoglobin in the general circulation and that in the spleen pulp which, it is shown, may attain thirty minutes. A similar lag which may attain ninety minutes in demonstration in rats which have been breathing CO and are exhaling this gas. - Authors' Conclusion

478. Barcroft, J., Murray, C.D., Orahovats, D., Sands, J., and Weiss, R.: The influence of the spleen in carbon monoxide poisoning. J. Physiol. 60:79-84, 1925.

In an atmosphere which receives a continuous accession of coal gas, guinea-pigs from which the spleens have been removed die sooner than either normal guinea-pigs, those from which omentum has been removed, or those from which one horn of the uterus has been excised.

Excision of the spleen four days prevously does not prejudice the length of life of guinea-pigs when exposed to an increasing concentration of hydrocyanic acid, a gas which kills by a means quite unconnected with haemoglobin.

The effects of removal of the spleen are not due to haemorrhage during the operation.

Having regard to the fact that in fatal pressure of carbon monoxide the spleen contracts, expelling its contents into the blood, it is suggested that the longer life of the normal animals is due to this accession of haemoglobin to the blood.

The percentage saturation of the blood with CO is almost the same in all the categories of animals. - Authors' Sum.

479. Beck, H.G., and Fort, W.: Chronic carbon monoxide poisoning. Ann. Clin. Med. 3:437-443, 1924-1925.

Two case studies of chronic carbon monoxide poisoning are discussed in detail in this paper. Because of the manifold and protean character of the clinical manifestations, only a few of the more common symptoms could be given in this paper. The pallor of many patients resembled a high grade of anemia, as well as a group of symptoms are suggestive of anemia in the presence of a red cell count of over 5,000,000. This condition is of considerable diagnostic significance. There is no specific antidote for chronic carbon monoxide poisoning and treatment has to be symptomatic.

An English bull dog was named the victim in a third case study of carbon monoxide poisoning. The blood examination showed a hemoglobin of 95%, erythrocytes 5,120,000 and leukocytes 12,250. There were no morphological changes in the red cells. - AGC

480. Behnke, A.R., White, W.A., Consolazio, W.J., and Pace, N.: A Study of Repeat Daily Short Exposure to High Concentrations of CO. U.S. Naval Med. Res. Inst., Bethesada, Md., Report No. 1, June 7, 1943, pp. 5.

It has been found that the breathing of uncontaminated air by men whose blood contain 20 to 23 per cent COHb results in the complete clearance of CO from their blood well within 24 hours. In fact, the elimination is practically complete within 8 hours after removal from air containing CO.

Four men at rest who breathed 20 parts per 10,000 of CO for 20 minutes daily for four consecutive days, and who reached blood levels of 23 per cent COHb by this exposure, failed to show any cumulative CO saturation of the blood.

Some of these men showed mild symptoms of CO anoxia during the course of the experiment. However, the symptoms did not appear to be progressive or cumilative, and all four men were symptom-free on the last day of exposure to CO.

If pure oxygen is breathed following exposure to CO, previous work indicates that the elimination time is reduced to a period of 30 to 60 minutes when compared with 8 hours for air.

In view of this and other evidence, it is concluded that short (i.e., 20 minutes) daily exposures to concentrations of 15 parts per 10,000 of CO as encountered on the ACV class of naval vessel is permissible for non-flying personnel in view of the emergency nature of the operations leading to such conditions. - Authors' Sum.

481. Brieger, H.: Carbon monoxide polycythemia. J. Indust. Hyg. & Toxicol. 26:321-327 (Dec.) 1944.

Polycythemia, a typical reaction to low oxygen saturation, is believed to be a regular sign of carbon monoxide asphyxia. It is supposed to compensate for the hemoglobin fixed to carbon monoxide and thus contribute in the defense of the organism. Gradual disappearance of the polycythemia follows as a rule the disappearance of carbon monoxide hemoglobin. Experiments described in this paper deal with acute and chronic carbon monoxide poisoning which furnish some new information on polycythemia in acute and chronic carbon monoxide poisoning. - AGC

481a. Candura, F., Craveri, A., and Brasca, F.: Fibrinolysis in acute carbon monoxide poisoning. Experimental research. Folia Med. (Naples) 44:400-408 (May) 1961.

In experiments with rabbits, the authors studied the fibrinolytic behavior of the blood serum following acute or fatal poisoning with city-gas (CO content of 1.8-5%). A constant and significant increase in the content of fibrinolysin or plasmin, was found. This resulting increase in the fibrinolytic power of the blood may explain the occasional finding of a fluidity of the post-mortem state of the

blood following a CO-poisoning death. No correlation was found between the rate of increase of fibrinolysis and the blood hemoglobin CO (HbCO) level. In view of the absence of any correlation, it is suggested by the authors that post-mortem blood fluidity--a finding which is not wholly characteristic of CO poisoning--might occur through nonspecific mechanisms which are brought into action by stress.
- APCA 4255

482. Candura, F., and Craveri, A.: Value and significance of fibrinolysis in experimental carbon monoxide intoxication. Rass. Med. Indust. 33:404-406 (May-Aug.) 1964.

Starting from the observation of the fluidity of the blood of subjects who have died from asphyxia, a study has been made on the behaviour of fibrinolysis in animals acutely intoxicated with carbon monoxide. The increase of fibrinolysis is found only in vivo, even in animals after removal of the adrenals. The removal of the spleen however, prevents the occurance of this process, so that two hypotheses may be advanced: the freeing of "ipossilienina" capable of orientig the blood coagulation towards hypocoagulability or the immission of splenin B in the circulation, a principle with a profibrinolytic activity. - Authors' Sum.

483. Carlsten, A., Holmgren, A., Linroth, K., Sjöstrand, T., and Ström, G.: Relationship between low values of alveolar carbon monoxide concentration and carboxyhemoglobin percentage in human blood. Acta Physiol. Scandinav. 31:62-74, 1954.

Alveolar CO concentration and COHb percentage in blood were determined in 55 subjects before and after exposure to low concentrations of CO.

Percentage of COHb in blood was found to increase in, approximately, direct relationship with increasing values of alveolar pCO within the investigated range (below 6% COHb), as predicted by Haldane's equation.

The mean value of M in Haldane's equation for the whole range of alveolar CO concentrations was 245.

When a small amount of CO was administered to a subject, the increase of COHb percentage was related to the increase of alveolar CO concentration by the value of M of 228 ± 6, S.D. 45 ± 5.

The variation of M in the material investigated could be explained as produced wholly by errors in measurement. Therefore, no real variation of M between different subjects could be established. - Authors' Sum.

484. Castellino, N., and Perla, V.: Carbon monoxide concentration in the blood. Folia Med. 42:209-222 (March) 1959.

Blood concentrations of carbon monoxide was measured in 302 patients: 46 with diabetes, 66 with gastrointestinal and hepatic disturbances, 38 with anemia, 30 with cardiac conditions, 74 with respiratory ailments, and in a group of patients with occupational diseases: 24 with caisson disease and 14 with lead poisoning. The readings were compared with those obtained from 100 normal subjects. In only a very few patients with uncompensated cardiocirculatory disturbances or respiratory diseases was any increase in the hematic CO level noted. The high concentration in these particular morbose conditions is attributed to incomplete CO elimination through the lungs, with a consequent build-up in the blood, rather than, as others have argued, to oxygen insufficiency, with a consequent failure to oxidize carbon to carbohydrate. Hence the presence of CO in the human bloodstream must be considered as of foreign origin. The wide variations observed, under normal as well as pathological conditions, simply reflect heavier absorption or a lowered elimination rate as a result of individual or environmental differences. - Authors' Sum.

485. Chiodi, H., Dill, D.B, Consolazio, F., and Horvath, S.M.: Respiratory and circulatory responses to acute carbon monoxide poisoning. Amer. J. Physiol. 134:683-693 (Nov. 1) 1941.

No hyperpnea was observable during rest in either dogs or men when subjected to acute and severe CO poisoning. The CO_2 combining capacity was unchanged, the arterial pCO_2 was increased, and accordingly the pH was shifted toward the acid side.

In severe CO poisoning the respiratory center was depressed.

The cardiac output showed no more than slight increases with HbCO saturations ranging up to 30 per cent. From that level up to 50 per cent HbCO the cardiac output increased as much as one-half.

The direct action on the respiratory center of the acute hypoxemia produced by CO poisoning that is severe yet compatible with life is purely depressive in nature.

From the data given the oxygen tension in venous blood can be calculated for various levels of HbCO. - Authors' Sum.

486. Chinn, H.I.: The Effect of Smoking at Simulated Altitudes on Carboxyhemoglobin Formation. School of Aviation Medicine, Randolph AFB, Texas, Feb. 29, 1944, 3 pp. DDC AD 121 707.

The carboxyhemoglobin concentration of blood in regular smokers (10 to 30 cigarettes daily) averaged 2.2 per cent of the total hemoglobin.

After smoking 4 cigarettes in 30 minutes, the concentration of carboxyhemoglobin rose to 3.9 per cent.

There was no significant difference between the carboxyhemoglobin concentration after smoking at ground levels or at simulated altitudes of 12,000 or 15,000 feet.

The increased carboxyhemoglobin after smoking is of little significance at ground levels but becomes increasingly important at altitudes above 10,000 feet. - Author's Abst.

487. Chovin, P.: Studies of Atmospheric Pollution in the Department of the Seine, in 1963. Municipal Laboratory Police Headquarters, Paris, France, 1964.

1963 test results for continuing studies in Paris, France, titled "Carbon Monoxide," "Policemen 1963," "Seine Loop," and "Smokeless Zones," are reported. Previous years' results are confirmed. Surface and underground tunnel measurements of CO in air are compared. The CO pollution level in the air went from "considerable" in 1962 to "serious" in 1963, but in the first 9 months of 1964, the situation reversed to that of 1962. The increase in 1963 is ascribed to the number of new roads and concurrent traffic increase. CO levels in blood were examined in a CO-exposed population consisting of industrial employees, auto drivers involved in accidents, and individuals suffering from CO exposure. Tests for "average real risk" of carbon monoxide absorption by individuals indicated that the auto drivers as a group had a much higher level of carbon monoxide in the blood than that of the rest of the population studied, including workers exposed professionally. - CBK (from French)

488. Curphey, T.J., Hood, L.P.L., and Perkins, N.M.: Carboxyhemoglobin in relation to air pollution and smoking. Arch. Environ. Health 10:179-185 (Feb.) 1965.

A total of 1,075 coroners' cases, for each of which a carbon monoxide blood concentration determination has been made, were classified as to smoking habits to ascertain what, if any, association existed between the carbon monoxide content in the ambient air, smoking history, and carboxyhemoglobin levels found in cadaver blood. Persons classified as nonsmokers were presumed to have been exposed in the last 24 hours of life only to atmospheric carbon monoxide.

Analysis of the data reveals that nonsmokers consistently had lower carbon monoxide values than smokers. In the one instance where analysis was possible on the basis of sex, the median value for male nonsmokers was greater by a factor of two, than for female nonsmokers. Graphically and by statistical analysis, the variables of age, location of examination, time of day, and day in week of death, maximum-minimum temperatures, or causes of death revealed little or no individual effect on carboxyhemoglobin levels. This was true for nonsmokers as well as for smokers. Smoking remained constant as the major variable associated with observed differences. When analysis was made to determine what association if any among nonsmokers existed between carboxyhemoglobin levels and ambient air carbon monoxide content, the association was significant ($p \leq 0.05$). This significant association was not noted for every location.

This study points out the potentialities of utilizing populations and other facilities of the chief medical examiner-coroner's office in furthering explorations in the field of air pollution research in general and the effects of carbon monoxide in particular. - Authors' Sum.

489. De Bruin, A., Vroege, D., and Van Haeringen, A.: Study of carbon monoxide uptake in traffic policemen. T. Soc. Geneesk. 43:146-151 (March 5) 1965.

The HbCO-content of the blood of 36 municipal traffic policemen--non-smokers--in Rotterdam exposed to exhaust from motor vehicles, during one to four hours, has been measured. The data were compared to those of a control group of 16 non-smoking policemen working in the office. Blood samples have been taken before and after work. The HbCO-content was on the average 0.93% before work and increased to 1.11% in the exposed group, whereas the HbCO-content in the control group remained about the same. The peak CO-content in the air was between 5-15 ppm. The chemical analysis has been performed with two independent methods. - APCA 65-154

490. Dominguez, A.M., Halstead, J.R., and Domanski, T.J.: Determination of Carboxyhemoglobin in Decomposed Bodies. Armed Forces Institute of Pathology, Washington, D.C., July 1963, 15 pp. DDC AD 420631.

The interpretation and the significance of carbon monoxide findings in cases associated with decomposition is studied. The evidence presented indicates that the percentage of carboxyhemoglobin saturation value is not markedly altered during postmortem decomposition when: (1) the specimens are properly preserved, and (2) the blood extracted from tissue is examined as soon as possible for the presence of carbon monoxide. It appears possible to obtain carbon monoxide values, utilizing blood extracted from tissue, in the presence of postmortem decomposition that are similar to the antemortem levels. For example, within the 4% to 12% carboxyhemoglobin-saturation range covered, there was neither a marked increase nor decrease in final percentage of carboxyhemoglobin following decomposition. Nevertheless, unreliable carboxyhemoglobin saturation values may occur. A gas-solid chromatographic procedure for determining carbon monoxide using blood or tissue is presented. This procedure employs a Van Slyke apparatus for liberating gases from biological specimens modified for introducing released gas into the gas chromatograph. - Authors' Abst.

491. Douglas, C.G., and Haldane, J.S.: Investigations by the carbon monoxide method on the oxygen tension of arterial blood. Skandinav. Arch. f. Physiol. 25:169-182, 1911.

This paper discusses various investigations of determining the oxygen tension of arterial blood. Animals were used in studying the carbon monoxide method. The theoretical basis, on which the carbon monoxide method of determining the arterial oxygen tension depends, has been carefully re-investigated. The method is based on the assumption that when blood is saturated with a mixture containing carbon monoxide and oxygen, the percentage saturation of the hemoglobin with carbon monoxide depends on the relative partial pressure of the oxygen and carbon monoxide, multiplied by a constant. Experiments on man were also attempted, using the same method as for small animals, in order to determine arterial oxygen tension. However, the method had to be modified because of the long time required to make certain that maximmm saturation of the blood has been attained. The paper is illustrated by graphs and tables. - AGC

492. Douglas, C.G., Haldane, J.S., and Haldane, J.B.S.: The laws of combination of haemoglobin with carbon monoxide and oxygen. J. Physiol. 44:275-304, 1912.

When a solution of haemoglobin, whether enclosed in blood corpuscles or free, is saturated in presence of a gas mixture containing oxygen and carbon monoxide, the ratio of oxyhaemoglobin to CO-haemoglobin is always proportional to the relative partial pressures of oxygen and carbon monoxide, and is not altered by the presence of CO_2, or slight changes in reaction, or of reduced haemoglobin, or by dilution, but is appreciably altered by temperature, as well as by light, and varies distinctly in the haemoglobin of different individuals and species.

The oxyhaemoglobin dissociation curves for the blood of two persons is given, and the results agree closely with Barcroft's. Curves are also given for mouse blood, which differ greatly from those for human blood.

Dissociation curves of CO-haemoglobin in presence of varying partial pressures of CO_2 are also given for human and mouse blood, and it is shown that the results vary, not only for different species, but also for different individuals. The curve for CO-haemoglobin has the same form as that for oxyhaemoglobin.

When blood is saturated in presence of such low partial pressures of oxygen and CO that reduced haemoglobin is present, the proportions of oxyhaemoglobin, CO-haemoglobin, and reduced haemoglobin can be calculated if the separate dissociation curves of oxyhaemoglobin and CO-haemoglobin are known; and in consequence of the form of these curves it follows that the presence of a small proportion of oxygen may greatly increase the formation of CO-haemoglobin, and vice versa. This paradoxical effect explains the favourable physiological effect sometimes produced by carbon monoxide in conditions of great anoxhaemia. The dissociation curve of the oxyhaemoglobin remaining in the blood when it is partially saturated with carbon monoxide can also be deduced; and the form of this curve explains the peculiarities of the symptoms of carbon monoxide poisoning as compared with those of anoxhaemia from other causes.

A theory, based on A.V. Hill's "aggregation" hypothesis, and on the work of Barcroft and his associates, as well as on our own observations, is put forward to account for the peculiar form of the dissociation curve of oxyhaemoglobin and CO-haemoglobin in blood or in salt-solutions, and the effects of CO_2 etc. on these curves. An equation for the curve, based on this theory, is also given, and is shown to correspond closely with the experimental data for human blood.

The differences in the relative affinities for oxygen and carbon monoxide in different samples of haemoglobin indicate that the average constitution of the globin part of the haemoglobin molecule varies, not only in different species, but also in different individuals of the same species. - Authors' Conclusion

493. Duvoir, M., and Gaultier, M.: Etiology: Clinical and chemical study of forty cases of chronic industrial carbon monoxide poisoning. Arch. Mal. Prof. 7:449-452, 1946.

Scepticism concerning the reality of chronic CO poisoning has been justified by the multiplicity of symptoms attributed to the disease. This paper attempts to establish chronic CO poisoning as a reality and as an individual disease by establishing a clinical and chemical basis.

Using Nicloux' method to determine the amount of CO in 40 subjects, a blood level above .4 to .5 cc. per 100 cc. blood is considered abnormally high. Cessation of exposure resulted in a gradual reduction of the blood level. In two months, one subject went from .85 to .52, another from 2.5 to .52, another from .82 to .46, etc. The blood level persisted for a longer time in a number of cases, a typical case being: .88 after exposure, .80 after 3 months, .30 after 5 months. Rest alone results in improvement, but oxygen therapy accelerates recovery. Vitamin B_2 also hastens return of blood levels to normal although its action is neither immediate nor constant.

Chronic CO poisoning is characterized by this elevated blood level and by three major symptoms, always appearing together. These are, 1) Asthenia. The asthenia is almost constant. Muscular fatigue, intellectual apathy, depression, slowness of speech, and impaired memory are frequently found, and sexual impotence is occasionally concurrent. 2) Severe headache. The headache is persistent, and usually more severe during exposure, although it may continue for several hours after work. It is not localized to any specific brain area. 3) Vertigo and syncope. Vertigo is frequent and may signal syncope. Syncope is a less important differentiation, since it is so often found in acute poisonings.

Pathogenesis and mechanisms remain obscure, but determination of blood level of CO, the constancy of symptoms, and improvement occurring during cessation of exposure are indicative of the reality of chronic CO poisoning.

494. Effenberger, E.: Carbon monoxide and its importance in hygiene. Med. Meteorolog. Hefte No. 12, 1957, 128 pp.

Author discusses in this reference work, besides general data, the problem of carbon monoxide with special consideration of the quantitative method of analysis of atmospheric and industrial air and in the blood. Small amounts of CO in the air are being generally analysed by the J_2O_5 method. According to the method by Fischingen, with minor changes by the author, which is described, it is possible to determine 0.001 Vol.-% of CO. Exact determination of CO quantities below 0.001 Vol.-% are still very difficult to obtain. The most sensitive methods at this time, the iodine and the COHb methods, are also only 7 to 10% accurate. The method for the determination of CO in the blood by Wolff is described and considered by the author to be the most simple and a more reliable procedure than the standard salt solution method. It also has the advantage that the color comparison can be performed independently of wave length of light and also of the color of serum. The accuracy of measurement increased to 3-5%. An extensive bibliography completes this volume. - AGC

495. Ehrich, W.E., Bellet, S., and Lewey, F.H.: Cardiac changes from CO poisoning. Amer. J. Med. Sc. 208:511-523, 1944.

Discussed in this paper are acute experiments at 40% carboxyhemoglobin and in chronic experiments at 21% carboxyhemoglobin or an equivalent oxygen deficiency, electrocardiographic and morphologic changes were seen, including inverted T wave, elevated R-T segment, and degenerative changes in individual muscle fibers. When the carboxyhemoglobin exceeded 75% for an hour or more, atrioventricular heart block and myocardial hemorrhage and necrosis supervened.

496. Engstedt, L.: Endogenous Formation of Carbon Monoxide in Hemolytic Disease. With Special Regard to Quantitative Comparisons to Other Hemolytic Indices. Acta Medica Scandinavica, Vol. 159, Suppl. 332, pp. 61, 1957.

During the last fifteen years the knowledge of erythrocyte and hemoglobin catabolism has rapidly increased. New isotope techniques have been useful tools, but other methods, for instance the old principle of differential agglutination of transfused erythrocytes, have also contributed to a great extent.

Bile pigments have long been known as end products of hemoglobin catabolism, and they have been used as an index of erythrocyte breakdown. A few years ago it was shown that there is a continuous formation of small amounts of carbon monoxide in man and that at least the greatest part of the exhaled carbon monoxide is formed during the break-down of hemoglobin. The formation of carbon monoxide during hemoglobin catabolism was also confirmed by studies in vitro.

However, it is not known to what extent carbon monoxide formation gives a quantitative estimation of hemoglobin break-down in clinical cases with increased hemolysis, or if increased carbon monoxide formation is a constant finding in such cases. "Erythrokinetic" studies have been done with various other methods, but determinations of carbon monoxide production have not been utilized for such investigation.

The present paper deals with quantitative comparisons between carbon monoxide formation and some other indices of hemoglobin break-down, and besides an evaluation of the practical value of the carbon monoxide method is made. - Author's Introduction

497. Fisher, M.B.: A summary of previous carbon monoxide studies. In: Conference Proc.: Health, Medical and Drug Factors in Highway Safety. 2nd Highway Safety Research Correlation Conference, April 5 & 6, 1954, Washington, D.C. Nat. Acad. Sc.-Nat. Res. Council Pub. 328, Sept. 1954, pp. 4.1-4.6.

Author relates the generally accepted physiological description of carbon monoxide poisoning, which basically is a process of anoxemia. The hemoglobin of the blood can take up either oxygen or carbon monoxide or a number of other materials. The problem arises because hemoglobin has a much greater affinity for CO than for oxygen. The ratio of these affinities is of the order of 210 to 1 with the result if there is any CO present in the atmosphere it will be taken up by the hemoglobin. Author states that the extent of variability in human behavior in response to various levels of CO in the atmosphere and to various levels of COHb in the blood as well as chronic CO poisoning needs further investigation. A.G.C.

498. Forbes, W.H., Dill, D.B., de Silva, H., and Van Deventer, F.M.: The influence of moderate carbon monoxide poisoning upon the ability to drive automobiles. J. Indust. Hyg. 19:598-603 (Dec.) 1937.

This paper reports the procedures and findings of what is probably the best research study on this subject so far conducted. Tests were made on eight normal male subjects with various percentages of carbon monoxide in the blood. These included measurement of the time required to remove the foot from the accelerator and the time to push down a brake pedal after a red light was flashed on; depth perception; ability to see dim objects at the side of a bright light; ability to perceive the approach or recession of objects; accuracy of steering.

These investigators found that the test performance was unaffected at a carboxyhemoglobin saturation level of 25% and was not disturbed until 30% was reached. The present investigators note that this value appears high as compared to present day concepts but observe that this study gives every impression of having been conducted with a high degree of competency.

499. Forbes, W.H., Sargent, F., and Roughton, F.J.W.: The rate of carbon monoxide uptake by normal men. Amer. J. Physiol. 143:594-608 (April) 1945.

New data are presented for the rate of carbon monoxide uptake by normal men at sea level, when exposed to air containing various percentages of carbon monoxide (0.01 to 2.0) and for various times. The subjects were at rest, light activity, light work or hard work.

A composite chart is given for calculating the average individual increase in percentage COHb in the blood with time, at varying CO pressure and varying ventilation rate. Particular individuals may however vary consistently by as much as ± 20 per cent from the data in the chart, which may therefore, in practical cases, often be replaced by much simpler approximate equations given in the text. Variations in the ratio of tidal air to dead space, and in the value of the diffusion constant of the lungs appear to be responsible for the differences between individuals in the rate of CO uptake.

The observed rates of CO uptake are lower than the average rates of most previous observers: the difference is attributed partly to more accurate estimation of COHb (by the Scholander-Roughton technique) and partly to adequate allowance for the blank CO already present in the blood before the exposure.

Lowering of the total barometric pressure (down to 140 mm. Hg) is without effect on the rate of CO uptake, provided the partial pressure of CO in the trachea is kept constant and correction is made for any increase in ventilation rate due to hypoxia.

Increasing the O_2 from 20 to 98 per cent at sea level decreases the rate of CO uptake: the effect is more pronounced in hard work than at rest. This decrease occurs because the rate of reaction of CO with Hb is inversely proportional to the O_2 pressure. - Authors' Sum.

500. Gemzell, C.A., Robbe, H., and Strom, G.: On the equilibration of carbon monoxide between human material and fetal circulation in vivo. Scandinav. J. Clin. & Lab. Invest. 10:372-378, 1958.

Measurements of COHb percentages in maternal and fetal blood immediately after normal delivery show a probable fetal/maternal ratio of about 1.5-1.6 when the mother has not been exposed to exogenous CO. If exogenous CO is administered to the mother before delivery, fetal uptake of CO occurs slowly, so that after 30 minutes of CO equilibration the fetal/maternal COHb percentage ratio decreases to about 0.5-0.6, later rising to values well above unity. Within 30 minutes of CO equilibration the fetal circulation has taken up only 1-2 percent or less of the amount of CO taken up by the maternal circulation. This result suggests that, in a pregnant woman, the overestimation of the maternal total amount of hemoglobin by the alveolar CO method which is due to fetal CO uptake should usually be negligible. - Authors' Sum.

501. Gettler, A.O., and Mattice, M.R.: The "normal" carbon monoxide content of the blood. J. A.M.A. 100:92-97 (Jan. 14) 1933.

This paper deals with investigations as to what extent carboxyhemoglobin exists in the blood of presumably normal persons as shown by a precise and delicate method. The literature reveals no record of such analyses.

Sodium fluoride is widely used in this country as an insecticide. Despite the fact that many fatalities have occurred following its accidental substitution for saline laxatives and baking powder, it is still widely dispensed without any indication that it is a poisonous substance.

One fatal case and seven nonfatal cases of accidental sodium fluoride poisoning were encountered at the Miami Valley Hospital, Dayton, within one month. The fatality resulted from the accidental substitution of sodium fluoride for epsom salt. The nonfatal cases resulted from the accidental substitution of sodium fluoride for baking powder in the preparation of biscuits. Since the labels on containers of insect powders containing sodium fluoride give no indication of its poisonous properties, such containers are commonly kept in medicine cabinets and in kitchen cupboards.

The toxic properties of sodium fluoride are not generally appreciated, largely because of the inadequate information, or misinformation, contained in textbooks on toxicology.

The urgent necessity for the proper labeling of containers of sodium fluoride-containing insecticides is apparent. - Authors' Sum. Modified

502. Gettler, A.O., and Freimuth, H.C.: Carbon monoxide in blood. Amer. J. Clin. Pathol. Tech. Sect. 7, pp. 79-82, 1943.

This paper discusses a rapid and simple method for estimating the carbon monoxide content in the blood. This method permits completion of determination within 15 minutes (excluding the preparation of standards, which will keep for several months) and requires no personal attention during this time. Principles involved, preparation of standard stains, and the methods are described. - AGC

503. Glantz, W.M., Stembridge, V.A., Dominguez, A.M., et al: Carbon monoxide determination in aircraft accident fatalities. Aerospace Med. 30:711-715 (Oct.) 1959.

Investigators at the Armed Forces Institute of Pathology have studied 747 cases of aircraft accident fatalities for the presence of carbon monoxide in postmortem tissues. All aircraft accident victims with carboxyhemoglobin elevations above 10 per cent were shown to have been alive at the time of the fire. Carboxyhemoglobin levels between 6 and 9 per cent saturation indicate the possibility that the subject was alive at the time of exposure to fire. Extensive fragmentation and postmortem incineration of tissues subsequent to explosive impact forces do not elevate the carboxyhemoglobin saturations. These investigators found no cases in which carbon monoxide intoxication has been implicated as the cause of an aircraft accident. - Authors' Sum.

504. Goldsmith, J.R., and Rogers, L.H.: Health hazards of automobile exhaust. Pub. Health Rep. 74:551-558 (June) 1959.

In Los Angeles, the air pollution from diesel engine exhaust is about 20 tons of organic emissions/day while that from automobile exhausts contributes about 1200 tons/day. Because the theoretical value (15:1) for air to fuel required for complete combustion is seldom maintained in automobiles, their exhausts frequently contain carbon monoxide, hydrogen, aldehydes, unburned hydrocarbons, sulfur oxides, and some lead compounds depending on the additives used. The constituents (in % of concentration, vol./vol.) of automobile exhausts are listed in table 1. Of these only carbon monoxide nitrogen oxides, lead compounds, and hydrocarbons are discussed in this paper. The max. CO concentration in Los Angeles, reported in table 2, is 93.2 ppm., with an average value of 15 to 36 ppm. British cities have reported an average of 4 to 20 ppm. with a max of 80 ppm. during smog. In Detroit, during heavy traffic an average of 28.9 ppm., with 80 ppm. max., has been reported. Although no health damage has been attributed to levels of CO below 100 ppm. there is undoubtedly some inactivation of hemoglobin. The level of CO saturation in the blood is greatly increased in tobacco smokers. Although experimental studies have shown an impaired adaptability of the eyes to darkness when young subjects were exposed to low levels of CO, this has not been shown by exposure to automobile exhausts at the levels found on city free-ways. It is, however, a plausible inference. The toxicity of nitrogen dioxide is based on its irritant properties, especially to the pulmonary membranes in cases of significant exposure, which are often delayed in onset. The nitrite ions formed when nitrogen dioxide dissolves are capable of forming the inactivated hemoglobin known as methemoglobin. Lead exposure by air pollution alone as reported by Los Angeles and other cities is usually not toxic but the small persistent amounts which could be contributed by auto exhausts may contribute to cases of toxicity in certain individuals working in garages and other work areas. Hygienic standards have been established for industrial exposure to CO, nitrogen dioxide, lead, and ozone. Establishing a full set of levels for community exposure is difficult because of the many variables involved, including the effect of agents in combination, the difference in sensitivity of ill persons, and the indeterminate period of exposure. The authors suggest that, in the absence of effective control for air pollution from automobile exhausts, the public health hazard should be evaluated. - APCA 2647

505. Goldsmith, J.R.: Some implications of ambient air quality standards. Arch. Environ. Health 4:151-167 (Feb.) 1962.

The impetus to set air pollution standards for California arose because of the recognition that the improvement - or even maintenance - in the quality of the air in California depended upon control methods for motor vehicle emissions. The law, which in addition to calling for public hearings and for revision of standards from time to time, states that "standards shall be so developed as to reflect the relationship between the intensity and composition of air pollution and the health, illness, including irritation to the senses, and death of human beings, as well as damage to vegetation and interference with visibility." Author discusses standards in other fields and compares industrial threshold limits, with maximal air pollution values, and the alert stages for toxic air pollutants in the Los Angeles County Air Pollution Control District. The community air pollution standards in the U.S.S.R. are also reviewed. Available facts and determination of whether or not standards could be set for, i.e., the group of photochemical oxidants, oxides of sulfur, and carbon monoxide are also considered. Because of the many sources for carbon monoxide exposure it was decided that only 5% of hemoglobin inactivation by community air pollution would become the basis for standards. Available data on reaction between hemoglobin and carbon monoxide were used to derive the standards - 30 ppm for 8 hours or 120 ppm for one hour. Because the basis of this effect is an interference with physiological function, the standard by definition is at the "serious" level. The 30 ppm standard averaged over 8 hours has often been exceeded in Los Angeles. In the Appendix the policy of the California Standards for ambient air quality are discussed in detail. - AGC.

506. Hackney, J.D., Lashier, H., Lynn, K., and Spier, C.: Comparative effect of two sources of exposure to carbon monoxide on carbon monoxide hemoglobin levels. Presented at the Air Pollution Research Conference on "Effects of Motor Vehicle Emissions on Health," Dec. 6, 1961, Los Angeles, Calif.

The comparative effect of two sources of carbon monoxide exposure, e.g., ambient CO and ambient CO plus cigarette smoke on the COHb of two normal subjects working as a team is discussed in this study. The rebreathing method for indirect estimation of COHb as previously described (1) was used in this study for the frequent monitoring of COHb. Samples of the ambient air were collected almost continuously during the experimental run as a means of representing the integrated total ambient CO exposure. - Authors' Introduction

507. Hackney, J.D., Kaufman, G.A., Lashier, H., and Lynn, K.: Rebreathing estimate of carbon monoxide hemoglobin. Arch. Environ. Health 5: 300-307 (Oct.) 1962.

Indirect methods of estimating COHb fall into 2 groups: rebreathing and breathholding. Rebreathing methods have the advantage of requiring less subject cooperation and aid in sampling alveolar gas. Normal subjects rebreathed 4 liters of oxygen for 2 minutes. Samples of 25 cc. were analyzed for oxygen and CO using gas chromatography. These results were substituted into the Haldane relationship (M value = 195). A total of 55 rebreathing estimates were compared with blood COHb measurements in normal subjects. There was good correlation between the estimated and measured COHb: Mean COHb 5.1%, the SD .22, coefficient of variation 4.4%. Using an assumed O concentration may lead to large errors in estimating the COHb. Previous rebreathing methods have utilized nitrogen wash out or other time consuming approaches. Our method requires 2 minutes and appears to have greater sensitivity. Preliminary studies on chronic lung disease subjects are reported. - Authors' Sum.

508. Haddon, W., Jr., Nesbitt, R.E.L., and Garcia, R.: Smoking and pregnancy: Carbon monoxide in blood during gestation and at term. Obstet. Gynec. 18:262-267 (Sept.) 1961.

Blood carbon monoxide (CO) concentrations in women seen in a prenatal clinic were significantly higher in smokers than in nonsmokers. Carbon monoxide concentrations in paired cord and maternal blood specimens obtained at term were found to be approximately equal, whereas CO concentrations per 100 gm. of hemoglobin were lower in cord than in paired maternal blood specimens. The differences between smokers and nonsmokers in the reduction in O_2-carrying capacity in the cord and maternal blood specimens, respectively, were also statistically significant. These reductions in maternal and fetal oxygen-carrying capacity and the action of CO as an enzyme inhibitor are discussed from the standpoint of their possible effects on fetal development. - Author's summary

509. Haggard, H.W., and Henderson, Y.: The treatment of carbon monoxide poisoning. J. AMA 77:1065-1967 (Oct. 1) 1921.

In the course of a large series of investigations the authors and their associates have marked out the following standard for exposure: "Multiply the time of exposure in hours by the concentration of the gas in parts per 10,000 of air. If the product equals 3 or less there is no appreciable physiologic effect. If it equals 6, there is sometimes slight malaise. If it equals 9, a headache with some nausea is produced in most people. If it equals 15, the conditions are dangerous for anything beyond brief exposure. If it is more than 15 they are extremely dangerous even for brief exposure."

In the proposed vehicular tunnel under the Hudson, carbon monoxide is not to be permitted to rise above 4 to 5 parts per 10,000, and the time for passage will be from fifteen to thirty minutes. Fieldner and his associates have shown that an automobile engine may produce from 1 to 2 cubic feet of carbon monoxide per minute. Thus, a car warming up in a small closed garage can make an atmosphere dangerous to life within five minutes. Production of carbon monoxide increases on a rich mixture and decreases on a thin one.

The whole toxicity of carbon monoxide has been shown to depend upon its union with hemoglobin.

The therapy of carbon monoxide poisoning depends on the hemoglobin combination and upon the fact that this combination is readily reversible.

510. Haldane, J.: The relation of the action of carbonic oxide to oxygen tension. J. Physiol. 18:201-217, 1895.

The poisonous action of carbonic oxide diminishes as the oxygen tension increases, and vice versa. At a tension of two atmospheres of oxygen this poisonous action is abolished in the case of mice.

The disappearance of the poisonous action is due to the fact that at high oxygen tensions the animals can dispense entirely with the oxygen-carrying function of haemoglobin.

The poisonous action of carbonic oxide is entirely due to its power of combining with the haemoglobin of the red corpuscles, and so putting them out of action as oxygen-carriers. - Author's Conclusion

511. Haldane, J.: The action of carbonic oxide on man. J. Physiol. 18:430-462, 1895.

Investigations to determine experimentally the causes of the symptoms produced in man by carbonic oxides are described in this paper. The relation of the changes in the blood to the symptoms, to the percentage of carbonic oxide breathed, and to the period during which the inhalation continued are particularly emphasized. - AGC

512. Haldane, J.B.S.: The dissociation of oxyhaemoglobin in human blood during partial CO poisoning. J. Physiol. 45:XXII-XXIV, 1912-1913.

This paper discusses the dissociation curve of oxyhaemoglobin in blood altered by the presence of a constant percentage of carboxylhaemoglobin. Curves are given for human blood in presence of 40 mm. pressure of CO_2. This study agrees with the observed fact that 50% saturation with CO is a serious condition, higher saturations producing coma. The comatose stage is longer, and death less sudden in CO poisoning than in asphyxia from simple O_2 want, because at low tensions more O_2 is liberated from the blood in the former case than the latter.

513. Halperin, M.H., Niven, J.I., McFarland, R.A., and Roughton, F.J.W.: Variations in visual thresholds during carbon monoxide and hypoxic anoxia. Fed. Proc. (Abstract) 6:120-121, 1947.

The comparative and combined effects of carbon monoxide and hypoxic anoxia on human visual intensity discrimination, as well as the effects of normal and high O_2 atmospheres during recovery from CO, were investigated.

In previous studies we have found that the measurement of visual intensity discrimination thresholds at a low level of illumination provides a very sensitive, useful and precise quantitative index of the physiological disturbance caused by oxygen deprivation. We therefore applied the same technique in measuring the effects of small amounts of CO. Extensive studies were carried out on four well-trained subjects.

A given increase in % COHb in the blood at sea level produces an effect approximately equal to that of an equal decrease in % O_2Hb due to hypoxic anoxia. At simulated high altitudes, a given % COHb produces an impairment equivalent to a further ascent which would cause an equal additional decrease in % O_2Hb. The visual threshold is therefore much more sensitive to CO than are other physiological functions so far investigated.

In studying the recovery from CO, we found that the inhalation of oxygen, in addition to its value in accelerating the elimination of CO, had another beneficial effect as compared with the inhalation of ordinary air. An added improvement equivalent to a decrease of about 5 to 7% COHb was produced by breathing oxygen. When the subjects then breathed ordinary air, the thresholds were again impaired by this amount. If, instead of oxygen, the subject breathed ordinary air throughout the recovery period, the visual thresholds failed to recover as rapidly as the % COHb declined. - Authors' Abst.

514. Hanson, H.B., and Hastings, A.B.: The effect of smoking on the carbon monoxide content of blood. J. A.M.A. 100:1481 (May 13) 1933.

In a short series of normal individuals who do not smoke, the hemoglobin of the blood was found to be saturated with carbon monoxide, 1.5 per cent.

In subjects who smoke the saturation of the blood with carbon monoxide was found to be from 3 to 4 per cent. - Authors' Conclusions

515. Hartridge, H.: The action of various conditions on carbon monoxide haemoglobin. J. Physiol., pp. 22-23, 1912.

The following factors are without influence on the final saturation of haemoglobin with CO: dilution, lactic acid, CO_2, certain acid and basic salts.

The following have a very marked influence: light, temperature, species.

With regard to the first, I have shown that investigation is simplified if the reaction can be made reversible, by addition of some chemical agent which removes the O_2Hb but leaves the undissociated COHb unaffected. The active rays are found to correspond to the absorption bands, those in the ultra violet being most active. The screening fluid employed in the spectroscope has been sufficient to reduce this light action to a minimum.

The dissociation is due to a change in the stability of COHb, and not to any alteration in the combination with oxygen.

Temperature has a most marked influence; the change in the saturation being about 1/2% for every 1 degree rise of temperature; it is therefore relatively more important at low, than at high temperature.

Equilibrium is reached at different saturations by the blood of animals of different species. - Author's Sum.

516. Henderson, Y., and Haggard, H.W.: The physiological principles governing ventilation when the air is contaminated with carbon monoxide. J. Indust. Eng. Chem. 14:229-236 (March) 1922.

With the building of tunnels under the Hudson River between New York and Jersey City for the principal use of motor vehicle problems have arisen which have never been extensively investigated. The investigations reported in this paper afford data upon which plans and designs for the ventilation of tunnels may be based. In the principal conclusions, authors state that the general standards agreed upon for periods of a few hours are: When the time in hours multiplied by the concentration of carbon monoxide in parts per 10,000 of air equals 3, there is no perceptible physiological effect. When it equals 6, there is a just perceptible effect. When it equals 9, headache and nausea are induced. When it equals 15 or more, the conditions are dangerous to life.

If the volume of breathing is increased by exercise (even by slow walking, and correspondingly more by physical work) the rate of absorption of carbon monoxide is increased proportionally.

After return to fresh air, the elimination of carbon monoxide through the lungs proceeds at a rate of 30 to 60 per cent reduction of the blood saturation per hour.

In the exhaust gas from gasoline, carbon monoxide is the only considerable toxic constituent. In the exhaust gas from coal distillate (benzene, etc.), and in illiminating gas, there are present accessory toxic substances. - Authors' Conclusions Modified -AGC

517. Heron, H.J.: The effects of smoking during pregnancy: A review with a preview. New Zealand Med. J. 61:545-548 (Nov.) 1962.

Carbon monoxide blood concentrations were found to be higher in maternal and foetal bloods in patients who smoked.

Respiration in infants of mothers who smoked took longer to establish and peripheral cyanosis was more common.

The condition of such infants appeared to revert to more nearly normal when they were placed in a high oxygen concentration for a short time. - Author's Sum.

518. Hofreuter, D.H., Catcott, E.J., and Xintaras, C.: Carboxyhemoglobin in men exposed to carbon monoxide. Arch. Environ. Health 4:81-85 (Jan.) 1962.

This study was designed to appraise the influence of exposure to various sources of carbon monoxide on carboxyhemoglobin levels. Also, the relationship of COHb levels with symptoms associated with CO intoxication was considered. Environmental factors such as smoking, occupational exposure, and commuting to work in a private automobile were not reflected in marked or sustained differences of COHb levels that could be related to these influences. No relation was found between symptoms and COHb values.

To summarize the effects of a rather continuous exposure throughout the day, 54 of the subjects were exposed daily to CO in their working environment, while smoking, and while commuting to work in a private automobile. The mean COHb value of this group was 3.8%. This mean was not markedly different from the mean levels observed in groups which had lesser exposure. - APCA 4298

519. Hurtado, A., Merino, C., and Delgado, E.: Influence of anoxemia on the hemopoietic activity. Arch. Internat. Med. 75:284-323, 1945.

The investigations to be reported in this paper concern the morphologic and other characteristics of the circulating blood under the influence of temporary, intermittent and chronic anoxic anoxia (anoxemia). Most of the work has been carried out at high altitudes and the results obtained have been compared with those observed in the study of healthy subjects at sea level and in previous related investigations. No attempt has been made to cover all the vast literature accumulated in this field. - Authors' Abst.

520. Hyperbaric oxygen in carbon monoxide poisoning. J. AMA 193:157 (July 19) 1965.

In "International Comments" of J. AMA there is a news note taken from "La Semaine Des Hopitaux Informations, Paris, April 14, 1965" in which is stated that Dr. Coulon, Chief, Neurorespiratory Reanimation Center at Garches, Paris, announced to Medical Society of Hospitals of Paris on March 26, 1965, that he found hyperbaric oxygen very rewarding in the treatment of carbon monoxide poisoning. Patients were kept in pressure cabinets made by Wickers Company of England, using an oxygen pressure of two atmospheres. In less than 10 minutes the carboxyhemoglobin content of the patients' blood began to decrease. Of 20 patients, 16 recovered and only four died. - CBK

521. Joels, N., and Pugh, L.G.C.E.: The carbon monoxide dissociation curve of human blood. J. Physiol. 142:63-77, 1958.

Carboxyhaemoglobin dissociation curves, in the absence of O_2, have been prepared for the blood of three subjects at CO_2 pressures of 15, 40 and 70 mm, Hg, and pH values of 7.50, 7.25 and 7.15, respectively. The determinations were made by equilibrating blood samples in tonometers with various concentrations of CO and measuring both the COHb saturation of the blood and the CO concentration in the tonometer gas at equilibrium.

These curves have been compared with the O_2Hb dissociation curves of the same three subjects, in the absence of CO, at the same CO_2 pressures and pH values. The effect of CO_2 on the COHb dissociation curves is shown to be very similar to though not identical with its effect on the O_2Hb dissociation curves.

The COHb dissociation curves differ slightly from the curves published by Douglas et al. (1912). Reasons for the differences are given.

The relative affinity of haemoglobin for CO and O_2 varies only slightly from subject to subject. On the other hand, it is affected by changes in plasma pH and CO_2 pressure, the relative affinity for CO rising as the pH increases and the CO_2 pressure falls. In these experiments, which were performed at 37° C, the ratio of the CO pressure producing 50% saturation with COHb the O_2 pressure producing 50% saturation with O_2Hb rose from an average value of 1:230 at pH 7.15 and pCO_2 70 mm Hg, to 1:260 at pH 7.50 and pCO_2 15 mm Hg.

The relative affinity as determined in this fashion from the 50% saturation pressures on the individual COHb and O_2Hb dissociation curves has been termed M*. The differences between this value and M, the ratio of the CO and O_2 pressures producing 50% COHb and 50% O_2Hb in a mixture containing no reduced haemoglobin, are discussed. - Authors' Sum.

522. Joels, N., and Neil, E.: Carotid chemoreceptor response to high carbon monoxide tension. J. Physiol. 156:5P-6P (Abstract), 1961.

The combination of as much as 80% of the blood haemoglobin with CO causes no carotid chemoreceptor discharge in cats breathing 1-2% CO in air, providing that the arterial pO_2 be not lowered (Duke, Green & Neil, 1952). The glomus cells normally betray a high oxygen usage (9ml./100 g/min). Their blood flow of 2000 ml./100 g/min (Daly, Lambertsen & Schweitzer, 1954) is, however, so high that they have little difficulty in extracting their large oxygen requirements without causing much fall in the local blood pO_2. Anoxic anoxia disrupts their oxidative metabolism, whereupon the chemoreceptor nerves display a vigorous impulse traffic. Cyanide also causes chemoreceptor discharge, and Anitschkov (1951) has assumed that the drug acts by inhibiting cytochrome oxidase. Cyanide, however, inhibits many of the enzymes which aid carbohydrate metabolism. Only carbon monoxide exerts a specific inhibition of cytochrome oxidase (Dixon & Webb, 1958). The affinity of cytochrome oxidase for CO is less than that for O_2. Thus it is necessary to use high CO tensions locally in glomus circulation in order to ascertain whether chemoreceptor discharge ascribable to cytochrome oxidase inhibition can be aroused.

Two sets of experiments were performed on cats anaesthetized with pentobarbitone.

1-2 ml. of blood (pCO = 300-500 mm, pO_2 = 150 mm, pCO_2 = 40 mm Hg) was injected locally into the carotid glomus circulation. Transient hyperpnoea and hypertension which occurred was abolished by cutting the relevant sinus nerve.

Electroneurography of chemoreceptor fibres showed that vigorous impulse activity was aroused by the perfusion of solutions equilibrated with pCO 300-500 mm Hg and normal pO_2 and pCO_2.

The inhibition of cytochrome oxidase thus does mimic the effect of anoxic anoxia on the glomus cells. It must be stressed that CO is used here as a biochemical tool; ordinarily in CO poisoning the tissue pCO is far too low to exert such histotoxic effects. - Authors' Abst.

523. Jones, J.G., and Walters, D.H.: A study of carboxyhaemoblobin levels in employees at an integrated steelworks. Ann. Occupat. Hyg. 5: 221-230, 1962.

Carboxyhaemoglobin levels at the beginning, and end, of a single shift's work in an integrated steelworks, are compared in 57 blast furnace employees and 63 employees not exposed to carbon monoxide at work. Results are presented in relation to smoking habits. The method of Whitehead and Worthington was used for the estimations and reasons for the choice, and tests of accuracy of the method, are given. Difficulties encountered in preparing standard concentrations of carboxyhaemoglobin are discussed. - Authors' Abst.

524. Killick, E.M.: Carbon monoxide anoxemia. Physiol. Rev. 20:313-344 (July) 1940.

Carbon monoxide derives its physiological interest from its property of combining with hemoglobin in a manner apparently identical with oxygen. The hemoglobin, however, has a very much greater affinity for carbon monoxide than for oxygen, and therefore carbon monoxide is a potent cause of anoxemia when it is mixed with the inspired air.

The combination of carbon monoxide with reduced hemoglobin, in the absence of oxygen, and the dissociation of carboxyhemoglobin, follow the same laws as govern the combination of oxygen with reduced hemoglobin and the dissociation of oxyhemoglobin. The curve relating the partial pressure of the gas to the percentage saturation of the hemoglobin is identical in shape for both gases, and its position is influenced by the same factors in both cases, for example, pH, temperature, and salt content (Douglas, Haldane and Haldane, 1912). The difference lies in the range of partial pressures; while the hemoglobin of human blood becomes half saturated with oxygen at a partial pressure of about 30 mm., it is half saturated with carbon monoxide, under the same conditions of temperature, pH, etc., when exposed to a partial pressure of about 0.125 mm. - Author's Introduction.

525. Korenevskaya, E.J.: The effect of high air temperature on the toxicity of carbon monoxide. Gigiena i Sanitaria No. 9, p. 19, 1955. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 1, 1960, pp. 46-52, CFSTI-TT-60-21049, U.S. Dept. of Commerce, Springfield, Va.

Studies of action of carbon monoxide at high air temperatures showed that the toxic effect of CO increased due to a complex of causes, with a rise in air temperature. At normal body temperature, even at 30-35° the increase in CO toxicity was slight. The thermoregulation mechanism was disturbed and the toxic effect of CO considerably intensified at an air temperature of 40-45°. Concentrations as low as 0.1 mg/l elicited clear symptoms of poisoning, and the general clinical picture indicated inhibition effects exerted by the CO on the functional capacity of the brain cortex. Experiments of the effect of CO on the physiological functions of the rabbit at different air temperatures are described. The accumulation and breakdown of carboxyhemoglobin in rabbits exposed to different carbon monoxide concentration at different air temperatures is shown in a graph. The effect of adaptation to high temperature on changes in physiological functions of animals exposed to 0.2 mg/l of carbon monoxide at 40° air temperature is also discussed. - AGC

526. Kraut, H.: Physiological-chemical effect of exhaust gases. Jahrb. brennkrafttechn. Ges. 20:7-16, 1939.

The physiological effect of motor exhaust gases is attributed mainly to the action of CO. The saturation of the blood hemoglobin with CO is given for the following concentrations (CO given in volume %): 0.01 - 12%, 0.02 - 22% and 0.04 - 36%. The saturation times decrease with increasing exertion. On inhalation of 0.03% of CO, an 18% saturation of the Hb is reached: during strenuous exercise, within 25 min., at rest, within 80 min. Description of various types of exposure to CO illustrates that a moderate charge of the Hb with CO, which does not produce acute symptoms, may noticeably reduce the exposed individual's capacity for physical exertion. The degree of dilution of car exhausts was studied in a 3-hour test drive through a narrow valley in the Harz mountains, in which 10 cars were used. The average CO content of the exhaust gases was (given in volume %) 4.0%, that of the surrounding air within 12 m. distance - 0.01 during driving and 0.026 during idling. - Kett.

527. Lawther, P.S.: The clinical significance of dirty air. Proc. Conf. National Smoke Abatement Soc., Oct. 1956.

Driving through London for 3 hours with the windows shut and the air intake on, investigator reported carbon monoxide concentrations of 130 ppm in the vehicle, the passengers' carboxyhemoglobin doubling over their previous control values. Although these levels were not harmful to the healthy passengers, author is unable to state, as yet, that they would not be of any significance to ill persons. This work is continuing. - AGC

528. Lilienthal, J.L., Jr., and Pine, M.B.: The effect of oxygen pressure on the uptake of carbon monoxide by man at sea level and at altitude. Amer. J. Physiol. 145:346-350, 1945.

The rate of uptake of CO has been studied in 9 subjects at rest under a variety of partial pressures of oxygen in the inspired air.

The rate of uptake of CO may be predicted with considerable accuracy for sea level and altitude conditions by means of the following relation of the "CO exposure index" to the increase in (COHb): Δ (COHb) = (pCO X time X minute respiratory volume) X 0.05.

In accordance with the laws of combination of CO with Hb in the presence of O_2, the rate of uptake of CO is inversely proportional to the partial pressure of O_2.

Total barometric pressure plays no discernible role in the uptake of CO.

The effects of minimal anoxia due to altitude sum with the effects of small amounts of circulating COHb to produce moderately severe symptoms of anoxia. - Authors' Sum.

529. Lilienthal, J.L., Jr., Riley, R.L., Proemmel, D.D., and Franke, R.E.: The relationships between carbon monoxide, oxygen and hemoglobin in the blood of man at altitude. Amer. J. Physiol. 145:351-358, 1946.

Three male subjects have been studied at varying pressure-altitudes while in equilibrium with inspired gas mixtures containing from 0.005 to 0.015 per cent carbon monoxide.

The distribution of COHb, O_2Hb and reduced Hb and their related gas tensions confirm in vivo the fundamental "laws" first defined by Haldane for the equilibria obtaining in vitro.

A simple rearrangement of the Haldane equation makes possible an accurate prediction of the amount of COHb obtaining when man is in equilibrium with a CO-contaminated atmosphere at any given altitude. The equation,

$$(\text{COHb}) = \frac{\text{MpCO}}{\text{pO}_2 + \text{MpCO}} \times (\text{Total hemoglobin saturation}),$$

requires only that the percentage of CO in inspired air and the pressure-altitude be known. The remainder of the terms may be read from standard values, tables and curves; e.g., M = 210, pO_2 = average alveolar tension at the given pressure-altitude, and (Total hemoglobin saturation), related to the tension of pO_2 + MpCO, may be read off the standard oxyhemoglobin dissociation curve.

The value of the relative affinity constant of Hb for CO compared to O_2 was found to be 204 ± 10 per cent in these experiments.

The total barometric pressure has been found to play no role in the distribution of CO and O_2 at equilibrium.

The hemoglobin of individuals who smoke appears not to differ from that of non-smokers in its affinity for CO and O_2.

The symptoms produced by CO are proportional not only to the blood concentration of COHb but also to the duration of exposure to a given concentration. - Authors' Sum.

530. Lilienthal, J.L., Jr., Riley, R.L., Proemmel, D.D., and Franke, R.E.: An experimental analysis in man of the oxygen pressure gradient from alveolar air to arterial blood during rest and exercise at sea level and at altitude. Amer. J. Physiol. 147:199-216, 1946.

By means of new technics, measurements have been made in man of the oxygen pressure gradient existing between the alveolar air and the peripheral arterial blood, during rest and exercise, at sea level and at simulated altitude.

At rest the gradient averaged 9 mm. Hg and during exercise 16.5 mm. Hg; the development of anoxia produced no significant changes in the size of the gradients.

A method is presented for differentiating the total alveolar arterial oxygen pressure gradient into its two main components: membrane resistance and venous admixture.

A theoretical analysis of the experimental data indicates that when the level of oxygenation was high (sea level) the observed pressure gradient resulted for the most part from the admixture of venous blood entering from poorly ventilated alveoli, the bronchial circulation, the Thebesian and anterior cardiac veins and perhaps other sources. By contrast, at low level oxygenation (anoxic anoxia) the gradient resulted largely from the pressure head which must develop across the pulmonary membrane to effect the transfer of the required volume of oxygen.

Exercise, by exerting a physiological stress on the mechanisms serving the transfer of oxygen from alveolar air to arterial blood, evokes an integrated series of respiratory and cardiovascular adaptations, one of which is the increase of the alveolar-arterial oxygen pressure gradient.

The diffusion constant of the lung, calculated from the experimental observations, averaged 21 at rest (range 12 to 36) and increased during exercise to an average of 62 (range 50 to 76). - Authors' Sum.

531. Lutmer, R.F., Busch, K.A., and DeLong, P.L.: Effect of nitric oxide, nitrogen dioxide, or ozone on blood carboxyhemoglobin concentrations during low-level carbon monoxide exposures. Internat. J. Air & Water Poll., in press.

Compared to exposure to CO alone, no enhancement of blood carboxyhemoglobin concentrations was observed following 7-hour exposures of rats and mice to low levels of CO plus NO, NO_2, or O_3. - Authors' Abst.

532. Mantell, C.D.: Smoking in pregnancy: The role played by carbonic anhydrase. New Zealand Med. J. 63:601-603 (Sept.) 1964.

An outline of the method used to estimate the carbonic anhydrase content in a specimen of cord blood has been given. This method involved the absorption of CO_2 by a buffer solution so as to lower its pH to the end point of the indicator.

Results show a decrease in carbonic anhydrase activity in the cord bloods of infants whose mothers smoked.

Classification at birth, length of gestation, and birth weights of the infants were also affected.

The differences in enzyme activity, foetal birth weights and condition, and the prematurity rate between infants of light and heavy smokers and between those who smoked and those who did not smoke during labour, were insignificant. - Author's Sum.

533. Marchiaro, G., Margaria, E., Gaido, P.C., and Aquaro, G.: Acid-base equilibrium in experimental acute intoxication from carbon monoxide. Rass. Med. Indust. 33:452-453 (May-Aug.) 1964.

In dogs experimentally intoxicated with CO a progressive decrease has been found in the pH values of the blood accompanied by an increase of the pCO_2. The acidosis condition tends to correct partially during the successive stages of treatment. - Authors' Sum.

534. Mayers, M.R.: Studies in Carbon Monoxide Poisoning. New York State Dept. of Labor, Div. Indust. Hyg. & Safety Standards, 1946, 64 pp.

This pamphlet contains six papers on the following subjects:

1. Carbon Monoxide Poisoning
2. Effects on Red Blood Cells
3. Carbon Monoxide Headache
4. In Garages'
5. In Hat Industry
6. In Foundries

Author states that there is need for further study of the toxicological effects of mixed gases, in which CO is one of the constituents, on both animals in the laboratory and on workers in industry.

Although it is assumed that, while the principal action of CO is undoubtedly the production of anoxemia by displacing oxygen from the hemoglobin of the red cells, it may in addition, have other physiological effects not yet fully understood. Whether CO is a tissue poison is still another matter for further investigation. - AGC

535. Meda, E.: Kinetics of the reaction of human hemoglobin with carbon monoxide. Rass. Med. Ind. (Rome) 33:292-295 (May-Aug.) 1964.

The author reports the results of studies on the kinetics of the reaction of human hemoglobin with carbon monoxide; the results were obtained with the use of the method termed "interrupted flow". The influence of temperature on the kinetics of the reaction was also studied and in addition the equation is given for calculating the speed constant. - APCA 64-176

536. Meigs, J.W.: Carbon monoxide poisoning. Bull. U.S. Army Dept. 8:542-546, 1948.

The danger of carbon monoxide poisoning among men working on gasoline-driven vehicles is emphasized. A concentration of several thousand parts per million may occur in the air near the exhaust outlet, even outdoors, unless exhaust gases are discharged so that the carbon monoxide is diluted before it can return to any area where it may be inhaled. Symptoms, which usually occur when the carboxy-haemoglobin content of the blood reaches 20 percent, include headache, dizziness, faintness, nausea, and vomiting. Samples of oxalated blood should be analyzed for the presence of carbon monoxide as soon as possible after exposure, to minimize reoxygenation of carboxy-haemoglobin, but they can be frozen and sent to a laboratory. The presence of a significant amount of carbon monoxide in the blood will differentiate symptoms due to carbon monoxide poisoning from those due to other causes, especially alcohol. Heavy cigarette smoking may produce carboxy-haemoglobin levels up to 10 percent.- BMB 402

537. Morgan, J.L.: Carbon monoxide poisoning-a danger of farm and home. Indust. Med. & Surg. 24:302-306 (July) 1955.

Carbon monoxide poisoning is a problem in Kansas as elsewhere. The gas when inhaled produces anoxemia by combining with hemoglobin. Pathologically the small blood vessels are the main target organs of the anoxemia and these vessel changes are so widespread that the clinical picture is extraordinarily variable. The diagnosis is usually suggested by the history or the surroundings in which the patient is found. There are simple qualitative blood tests which may help to detect carboxyhemoglobin. Treatment is based on ventilating the patien't lungs with fresh air or a carbon dioxide-oxygen mixture. Permanent sequellae such as psychoses and Parkinsonism do occur but they are extremely rare. Chronic carbon monoxide poisoning is a debatable entity. -Author's Sum.

538. Moureu, H., Chovin, P., Truffert, T., and Lebbe, J.: Some lessons drawn from determinations of carbon monoxide poisoning of city inhabitants. Compt. Rend. (Paris) 247:552-555 (July 28) 1958.

The use of a simple but exact infrared absorption technique to determine the amount of CO in the blood and in the ambient atmosphere is reported. Two experiments were made to study the effects of automobile exhaust gases on 36 volunteer subjects stationed on selected streets and intersections in Paris. The amount of CO in the blood of the subjects was determined immediately before and after a 3-hour period at a test station, and simultaneously 2 or 3 air samples were made to determine percentages of oxygen and CO. The atmospheric conditions and intensity of auto traffic were noted at each station. The first test was made on January 15, 1957, between 9 A.M. and 12 noon; a relatively strong NE wind (20-30 km./hour) prevailed to disperse exhaust gases. The average amount of CO in the air was 8 ppm. The average amount in the blood before exposure (0.35 ml./100 ml. blood), increased about 25% to 0.44 ml. A second test was made 7 days later between 4 and 7 P.M.; wind had been nearly absent for several days and a slight tendency to fog was present. A rise in the initial CO content of the blood was noted, averaging 0.54 ml./100 ml. blood, i.e., slightly exceeding the normal limit for city dwellers of 0.4 ml. The average CO content of 100 samples of air was 26 ppm. The increase in the CO content of the blood at the end of the test period was marked: 0.11 ml., i.e., a 31% increase. Similar tests were made of 136 samples of blood of automobile drivers held on charge of intoxication after an auto accident or traffic offense. Results were statistically analyzed in comparison to 4507 cases suspected of CO poisoning. CO levels in the blood of the intoxicated drivers were found to be much greater than among the controls. - APCA 2023

539. Moureu, H.: The various aspects of pollution by the exhaust gases of motors of internal combustion. Rev. Pathol. Gen. Physiol. Clin. (Paris) 61:915-931 (July) 1961.

Although automotive traffic has not reached the density in Paris that it has in Los Angeles, it is increasing rapidly. Concern for this type of pollution, especially that from ozone and carbon monoxide, was felt for the drivers of automobiles and for pedestrians involved in heavy traffic. A chart in the text compares carboxyhemoglobin (HbCO) levels of a group (303 persons) of automobile drivers, another group of professional personnel (867 persons) exposed to CO, and another of controls (435 persons). In a range of blood levels of 0.2 to 2.5 ml./100 ml. of blood, a greater number of drivers had levels in the higher half of this range. At a level marked in the table as "serious" (1.2 ml./100 ml.), nearly 40% of the drivers, less than 25% of the workers, and only about 7% of the controls were higher. The technical solution of the control of exhaust gases has probably now been solved by American manufacturers with equipment, developed past the laboratory stage, which will not be prohibitive in cost. The controversies over the use of diesel motors have also become resolved with the decision being that well-run and well-maintained diesel motors produce little exhaust. The international colloquium on atmospheric pollution, which was held in Royaumont in April 1960, included among its recommendations the dieselization of public transport. It has been established that the level of CO pollution in the public gardens is 5 times less than on busy streets. Wide avenues and areas of greenery are imperative in control of this type of air pollution. Again the running conditions of the motor are so important in controlling the degree of pollution that they should be under official supervision and inspection. In large cities, especially, the running of motors at an idling level should be reduced to a minimum. - APCA 4635

540. Pace, N., Consolazio, W.V., Pitts, G.C., and Pecora, L.J.: The rate of blood absorption of low concentrations of carbon monoxide in ambient air at simulated altitudes up to 10,000 feet. NMRI Project X-417, Report No. 2, Aug. 31, 1944.

Tests of 3 to 5 hours' duration were conducted at a simulated altitude of 10,000 feet (520 mm. Hg), in which subjects breathed CO concentrations of 0.87 parts/10,000 and 1.79 parts/10,000 by means of a demand system and A-14 mask. Analyses of "arterialized" blood withdrawn from veins of the heated hand, and measurements of pulse rate and respiratory minute volume were made. The altitude decrement attributable to the presence of given amounts of COHb was not ascertained. This problem is now being studied.

The results of these tests permit the following statements:

At the end of 5 hours' exposure at 10,000 feet, the inhalation of 1.79 parts/10,000 CO was accompanied by an uptake of not more than 12 per cent COHb.

The rate of uptake of CO follows a predictable course in a range of concentrations from 0.87 parts/10,000 to 20 parts/10,000.

The blood level of COHb may be predicted over the range by the equation:

$$\Delta \%\text{COHb} = \frac{\text{Parts CO x Corr. Min. Vol. x Time}}{\text{42.5 x Blood Vol.}}$$

The effect of altitude is taken into account by correcting the minute volume of respiration, as measured at altitude, to STP.

The experimental data show close agreement with calculations based on theoretical values obtained by means of the equation.

The time of exposure required to reach a given blood level of COHb in relation to the CO concentration in ambient air can be computed within the limits of experimental error for sea level, and for various altitudes up to 10,000 feet.

A summary of the data obtained in this study was prepared for limited distribution as Report No. One. - Authors' Sum.

541. Pace, N.: Limits of Tolerance for Carbon Monoxide Under Working Conditions and in Emergency Procedures Aboard Ship. Naval Med. Res. Inst., Nat. Naval Med. Center, Bethesda, Md., NM6-1/All/NMR1-124, June 12, 1945.

This report is made in response to a request from BuShips for information regarding the limits of tolerance of exposure to various concentrations of carbon monoxide. The limits set forth herein pertain only to non-flying personnel, and must not be applied in other situations where lowered atmospheric oxygen tensions may also be encountered.

Recent work at the Naval Medical Research Institute has led to the development of a general equation for the expression of the rate of accumulation of carbon monoxide in the blood in terms of the factors important to the process. The equation described in this paper has been tested under a wide variety of conditions and found to hold well experimentally and in practice. - Author's Abst.

542. Pace, N., Consolazio, W.V., White, W.A., Jr., and Behnke, A.R.: Formulation of the principal factors affecting the rate of uptake of carbon monoxide by man. Amer. J. Physiol. 147:352-359, 1946.

The rate of uptake of carbon monoxide has been shown to be constant with respect to blood concentration of COHb, up to values of one-third the equilibrium level, when air containing CO in the range 1 part to 20 parts per 10,000 is breathed by men at rest or engaged in moderate physical activity.

An equation has been derived which serves as a means of estimating in man the degree of blood saturation with CO as a result of exposure to air containing this gas as follows:

$$\Delta \text{ per cent COHb} = \frac{\text{Parts CO X Minute Volume X Exposure Time}}{\text{46.5 X Blood Volume}}$$

The equation is valid for values of per cent COHb up to one-third the equilibrium value for the air concentration of CO under consideration. Within this range Δ per cent COHb may be estimated within a degree of error whose standard deviation is ±2.3 per cent COHb.

The fraction of CO removed from the inspired air by the blood was found to be constant as uptake progressed, and the mean for a group of twelve men was 41.2 per cent with a standard deviation of ±4.4 per cent. This value is somewhat lower than that observed by previous investigators. - Authors' Sum.

543. Parmeggiani, L., and Gilardi, F.: Physiological levels of blood carbon monoxide. Med. Lavoro 43:179-183 (April) 1952.

Values for HbCO in the blood of 34 normal subjects both non-smokers and smokers of 10-40 cigarettes per diem were assessed with the Heilmeyer method and Koenig-Martens spectrophotometer. The non-smokers showed an average level of 2.8% with a 4% maximum, the moderate smokers an averave of 4.9% with a maximum of 9%, while in the case of the heavier smokers, concentrations of HbCO up to 14% were found. For the practical exercise of occupational and insurance medicine the upper limit for the physiological carbon monoxide level should therefore be fixed at, at least 10% of HbCO, a concentration currently observed in the blood of workers who are smokers, but not exposed to sources of occupational carbon monoxide. Higher figures are signs of absorption of CO, higher than those for average smokers, but still not signs (in the absence of clinical symptoms of poisoning) of carbon monoxide poisoning. - Authors' Sum.

544. Pecora, L., Vecchione, C., and Fati, S.: On the binding of carbon monoxide in the blood in acute and chronic carbon monoxide poisoning. Folia Med. 43:568-580 (June) 1960.

Experimental studies in vitro were made by the authors of the stability of the carbon monoxide linkage with the blood subsequent to acute or chronic poisoning. In acute poisoning a group of 12 rabbits were exposed on the 1st, 5th, 10th, and 20th days; in chronic poisoning a similar group of rabbits were exposed for 120 days with the carbon monoxide at a level of 100 ppm. For each type of poisoning the CO levels were determined for newly-drawn samples of blood and of samples which had been exposed to the air for varying periods. From results of these studies it was shown that the greater the number of acute poisonings, or the more prolonged the chronic poisoning, the less was the quantity of CO freed from the red cells or from the plasma after exposure to air. There was, therefore, a progressive increase in both the plasma and globulin carboxyemia. From these studies it is evident that in repeated poisonings CO is not only distributed in the blood in a different way compared with single poisonings, but also that links which are unlikely to be reversible are established both in the plasma and in the red blood cells. - APCA 4021

545. Pitts, G.C., and Pace, N.: The rate of blood absorption of low concentrations of carbon monoxide at sea level. Naval Medical Res. Inst., Bethesda, Md., Res. Project X-417, Rep. No. 6, Feb. 1945.

Two tests of twelve and seven hours' duration respectively were conducted at sea level upon supine subjects breathing, by means of a demand system and an A-14 mask, CO concentrations of 89 ppm. and 156 ppm. The per cent saturation of hemoglobin with carbon monoxide was determined each hour. The subjects were ventilating at a rate of approximately 6.7 liters per minute.

The results of these tests permit the following statements:

Twelve hours' exposure of one subject to 89 ppm. CO resulted in a carboxyhemoglobin (COHb) concentration of 11.0 per cent.

Seven hours' exposure of one subject to 156 ppm. CO resulted in a COHb concentration of 16.6 per cent.

The course of the respective uptake curves indicates that during the time of exposure neither subject attained final equilibrium with the CO concentration being breathed.

The equilibrium concentrations of COHb are roughly estimated to be from 13 to 15 and from 30 to 40 per cent respectively for the 89 ppm. and 156 ppm. CO mixtures.

The results indicate the desirability of further work on rate of uptake of low concentrations of CO at higher rates of ventilation. - Authors' Sum. and Conclusions

546. Portheine, F.: Carbon monoxide and traffic. Arch. f. Gewerbepath. u. Gewerbehyg. 13:253-261, 1954.

Carboxyhemoglobin saturation per cent of blood samples of 200 automotive vehicle drivers whose blood was sampled by the police in Dusseldorf primarily for alcohol content was from zero through 5% for 65.5% of the subjects, 6-10% for 27%, 11-15% for 6.5%, with one subject at 16% and at 20%. At a high traffic street crossing in the Ruhr area, traffic officers were found to show 18% Co-Hb in the blood immediately at the completion of duty.

547. Ricci, C., Capellaro, F., and Gaido, P.C.: Electrophoretic and immuno-electrophoretic examinations in workers exposed to chronic CO intoxication. Rass. Med. Indust. 33:414-416 (May-Aug.) 1964.

The authors have examined the behaviour of the transferrin with immunochemical methods in individuals exposed to occupational risks from CO. In all the subjects an increase was noted in the globulin fraction of the serum regardless of the time of exposure an increase particularly linked to the globulin fraction (transferrin or siderophillin). - Authors' Sum.

548. Roberts, W.C.: Correlation of blood carbon monoxide level with symptoms. Indust. Med. & Surg. 21:323-325 (June) 1952.

26 cases of intoxication by carbon monoxide are reported in this paper attempting to show the correlation, if any, between symptoms and physical findings seen, and carbon monoxide blood saturation levels.

It is concluded that there is no close correlation of physical findings and symptoms with carbon monoxide blood levels. The physiological reactions to carbon monoxide may vary with the state of health of the individual, or the presence of fatigue. In some cases frequent small exposures to carbon monoxide may develop a considerable degree of acclimatization, and thus alter the physiological reactions to carbon monoxide. - Author's Sum.

549. Roughton, F.J.W., and Darling, R.C.: The effect of carbon monoxide on the oxyhemoglobin dissociation curve. Amer. J. Physiol. 141: 17-31 (March 1) 1944.

A simplified method is proposed for calculating the O_2-dissociation curve of O_2Hb in the presence of a given percent of COHb. It utilizes the observed dissociation curve of O_2Hb without CO and the theoretical assumptions of the partition of Hb between O_2 and CO; but avoids any equation for the hemoglobin dissociation curve and does not require the choice of a numerical value for the partition coefficient M.

The theory was tested in hemoglobin solutions in 0.6 M phosphate buffer pH 7.4 at two percentages of COHb and found to agree excellently with four out of six observed points, and the discrepancy in the remaining two was not very serious.

Whole blood showed generally excellent agreement between theory and observation when similarly tested at $pCO_2 = 40$ per cent and COHb approximately 20, 40, 60 per cent, and at $pCO_2 = 25$; per cent COHb = 22.

The relation of the fundamental assumptions of the theory to the intermediate compound hypothesis of the O_2-hemoglobin equilibrium is worked out.

It is shown that the effect of COHb on the O_2-dissociation curve in vivo should be quantitatively the same as the experimentally observed effect in vitro.

Plotting of O_2 pressure against total bound O_2 rather than against the fraction of the available hemoglobin bound with O_2 is shown to give clearer indications of the effect of COHb on the transport of O_2. In particular the conditions under which a, O_2 supply would begin to fail, and b, small amounts of CO would have a beneficial effect at very low O_2 pressures (Haldane-Smith effect) are demonstrated. - Authors' Sum.

550. Roughton, F.J.W.: The average time spent by the blood in the human lung capillary and its relation to the rates of CO uptake and elimination in man. Amer. J. Physiol. 143:621-633 (April) 1945.

The average time, t_L, which the blood spends in passing through the lung capillaries is of interest, since it is only during this phase of the circulatory cycle that exchange of gases between the blood and air is possible. A knowledge of the value of t_L is therefore important in several kinetic problems of respiration.

A theoretical method of calculating t_L is described and its reliability critically discussed. Its accuracy in normal man is believed to be of the order of ± 30 per cent.

The average value is 0.75 ± 0.25 second for normal men at rest, and 0.34 ± 0.1 second in hard work. These values are of the order of magnitude to be expected from other physiological data.

The total volume of the blood in the patent lung capillaries is also calculated from t_L. In normal men it averages 60 cc. at rest and 95 cc. in hard work, thus indicating that no very extensive opening up of extra capillaries occurs in the lungs during exercise.

Applications of the new data to the kinetics of CO uptake and elimination in the lungs of man are discussed. - Author's Sum.

551. Roughton, F.J.W., and Root, W.S.: The fate of CO in the body during recovery from mild carbon monoxide poisoning in man. Amer. J. Physiol. 145:239-252, 1945.

Analyses are given of the CO content of expired air and of the progressive fall in CO content of the blood during recovery from mild CO poisoning. From such figures, together with the blood volume, the percentage of CO recovered in the expired air is calculated.

In normal men, whether breathing oxygen or air, the CO found in the expired air only averages 60 to 70 per cent of that currently lost from the blood during the first hour after the CO administration. Independent theoretical calculations confirm the validity of this result.

If, however, the subjects continue to breathe oxygen for 4 hours after the CO administration, about 96 per cent of the CO initially absorbed by the subject is recovered in the expired air over this longer period. It is inferred that the 30 to 40 per cent fraction of CO, lost from the blood during the first hour and unaccounted for in the expired air, must have combined reversibly with hemoglobin-like pigments outside the main blood stream. Subsequently as the blood CO content falls, the CO dissociates reversibly from these combinations, diffuses back into the blood and thence into the expired air.

The results of the four hour experiments confirm previous views that there is no significant loss of CO (a) through the skin, sweat, urine, or feces, (b) by oxidation or other forms of metabolism--at all events in mild CO poisoning and with the body adequately supplied with oxygen.

The possible sites for this extra-circulatory combination of CO are considered and its implications in regard to blood volume determinations and other aspects of the chemical physiology of CO are discussed. - Authors' Sum.

552. Sakurai, Y.: The study of the skin permeability of carbon monoxide and measurement of carboxyhaemoglobin in blood. Japan J. Legal Med. (Tokyo) 17:314-326 (July) 1963.

The question had been raised at an earlier scientific meeting of the extent to which the skin was permeable to carbon monoxide gas. Basic in vitro studies were 1st made, using a photometric spectrophotometer, on prepared fresh blood samples into which fuel gas containing 7% CO had been introduced. In later studies, blood samples were taken periodically from a recently-killed guinea pig which was confined to a desiccator into which the same fuel gas was introduced. Results showed that CO did penetrate through the skin of the animal to combine with the hemoglobin of the blood to form carboxyhemoglobin (HbCO). A live rabbit was confined, except for its head, in an airtight box and the fuel gas was introduced and vented from the box. Blood samples were taken periodically from an ear vein. In a series of 3 rabbits so exposed, CO was found to have penetrated the skin and entered the blood to form HbCO. There was some indication that the normal defense mechanisms of the living body had been operating for a while to eliminate the CO from the body. However, these defense mechanisms were overcome and the rabbits died after 31, 25, and 10 hours respectively. It was concluded from these experiments that there was a decided degree of skin permeability to CO. - APCA 5875

553. Sayers, R.R., Meriwether, F.V., and Yant, W.P.: Physiological effects of exposure to low concentrations of carbon monoxide. Pub. Health Rep. 37:1126-1142 (May 12) 1922.

The combination of CO with hemoglobin takes place slowly when the subject is exposed to low concentrations and remains at rest, many hours being required before equilibrium is reached.

The rate of combination of CO with hemoglobin takes place much more rapidly during the first hour of exposure than during any succeeding hour, with the subject remaining at rest.

Strenuous exercise causes much more rapid combination of CO with hemoglobin than when the subject remains at rest. The symptoms of CO poisoning are emphasized by exercise.

High temperature and humidity, with a given concentration of CO, cause more rapid combination of CO with hemoglobin than do normal conditions of temperature and humidity.

All symptoms and effects described in this paper are called acute in character. None of the subjects has shown any permanent deleterious effects from the exposure to CO. - Authors' Conclusion

554. Sayers, RR., Yant, W.P., Levy, E., and Fulton, W.B.: Effects of repeated daily exposure of several hours to small amounts of automobile exhaust gas. USPHSB No. 186, 1929, 58 pp.

Six men were exposed in a chamber from 4 to 7 hours daily, for 68 days, to gasoline engine exhaust containing 200, 300, and 400 ppm of carbon monoxide. At 200 ppm, carboxyhemoglobin reached 25 percent in 5 or 6 hours; more than one-half the subjects experienced no symptoms at all, the remainder suffering slight discomfort in 2 hours and frontal headache in 4 hours. At 300 ppm and at 400 ppm, carboxyhemoglobin reached 30 percent, within 5 and 4 hours respectively. At the higher concentration, more than 90 percent of subjects suffered frontal headache within 4 hours, and a few complained of occipital headache. No deleterious effects upon health or well-being were detected, and psychologic examination revealed only a slight tendency to poorer performance in the prolonged steadiness test. A definite increase in hemoglobin and red blood cell count was noted.

555. Schulte, JH.: Effects of mild carbon monoxide intoxication. Arch. Environ. Health 7:524-37 (Nov.) 1963.

The effects of exposures for varying lengths of time to an atmosphere containing 100 ppm. of carbon monoxide were measured in a group of 49 healthy men between 25 and 55 years of age. This exposure produced levels of carboxyhemoglobin in the blood of the subjects ranging from 0-20%. Impairment of function due to exposure to CO occurred earliest in the higher centers of the central nervous system in that area (or areas) of the brain which controls some of the cognitive and psychomotor abilities. Impairment is detectable at levels of carboxyhemoglobin below 5%, and the degree of impairment increases with increasing concentration of the carboxyhemoglobin in the blood. The need for reducing the max. allowable concentration of CO in the working environment has been speculated upon. - APCA 5699

556. Sievers, R.F., Edwards, T.I., and Murray, A.L.: A Medical Study of Men Exposed to Measured Amounts of Carbon Monoxide in the Holland Tunnel for 13 Years. Federal Security Agency, U.S. PHSB No. 278, 1942, Washington, D. C., 74 pp, and J. AMA 118:585-588 (Feb.21) 1942.

Medical examinations of 156 traffic officers on duty at the Holland Tunnel for 13 years and four months were made as a practical test of the effectiveness of the medical and engineering control methods set up for their protection. About half of these officers had been on tunnel duty every working day of this period. Average carbon monoxide exposure throughout the tunnel for all hours of the day was approximately 70 ppm. Results of medical examinations of men on duty for the first five years showed them to be in excellent physical conditions. No evidence of symptoms attributable to carbon monoxide intoxication and for sequelae of acute episodes was found. The effects of both smoking habits and of occupational exposure to carbon monoxide concentrations in blood samples were analyzed by the Van Slyke method. The lowest concentration value, expressed as percent of hemoglobin combined with carbon monoxide, was 0.5; the highest value was found in a tunnel officer, a heavy smoker, coming directly from unusually heavy atmospheric exposure, was 13.1. No signs or symptoms attributable to carbon monoxide were observed within this range. Concentrations of carbon monoxide in the blood of toll collectors on the holiday selected for observation ranged up to 15.1 percent, expressed as percent of hemoglobin combined with carbon monoxide.

Authors do not feel that there is reason to assume that prolonged exposure to these concentration levels will result in injury to health. Precautions in force in the Holland Tunnel set up for the elimination of the possibility of acute exposure is to be extended in order to protect the health of all persons unavoidably exposed to carbon monoxide. - Authors' Abst. Modified-AGC

557. Smith, P.K.: Carboxyhemoglobin Concentrations in Personnel After Flying P-40-N Aircraft. School of Aviation Medicare, Randolph AFB, Texas, May 5, 1945, 3 pp. DDC AD 121708.

Measurements were made of the carboxyhemoglobin concentrations in eighteen pilots after flying fourteen different P-40-N aircraft. The concentrations of carboxyhemoglobin varied from zero to eight per cent of the total hemoglobin. It is concluded that the concentrations of carboxyhemoglobin found were probably not high enough to interfere with flying efficiency. - Author's Abst.

558. Sterz, H.: On hemoglobinemia. Medizinische Klinik 58:1705-1709 (Oct. 18) 1963.

In discussing the pathology of hemoglobin as prevailing in people of various geographic areas, the author treats also of the most common occurrence of hematologic changes caused by CO poisoning. CO has a 200 to 300 times greater affinity for Hb than oxygen and 0.1% of CO in the air is sufficient to impede half of the Hb necessary for the function of breathing. Severe headache, restlessness, shaking, weakness, cramps, deep coma, paralysis and death may be caused by the paralysis of the breathing mechanism and by hemorrhage in the brain. About 60% CO-Hb in blood causes coma, 70-80% are fatal. Chronic conditions may develop at exposures above 20%. CO concentrations should be kept below 20% the maximum limit. - From German AGC

559. Trompeo, G., Gaido, P.C., and Capellaro, F.: Concentrations of carbon monoxide in the air and carboxyhemoglobinemia (study on garage mechanics). Rass. Med. Indust. 33:440-442 (May-Aug.) 1964.

Measurements have been made of the carboxyhemoglobinemia in workmen in an underground garage at the end of a working day. The average of the values was found to be higher than those of smokers who were not to other sources of carbon monoxide and in addition it was possible to note a close relation between the maximum carboxyhemoglobinemia values and values of CO in the surroundings. - Authors' Sum.

560. Van Slyke, D.D.: Gasometric determination of the oxygen and hemoglobin of blood. J. Biol. Chem. 33:127-132, 1918.

The apparatus described by Van Slyke in J. Biol. Chem. 30:347, 1917, for determining the carbonic acid content of plasma may be used with equal facility for determining the oxygen content and the oxygen-binding capacity (hemoglobin) of blood. The oxygen is set free from combination with hemoglobin within the apparatus by addition of ferricyanide, is extracted in a Toricellian vacuum, and measured at atmospheric pressure, a few minutes sufficing for an accurate determination. - Author's Sum.

561. Vasil'eva, A.A., and Manita, M.D.: Carboxyhemoglobin in the blood of persons directing city traffic. Gigiena i Sanitaria 25:77-80 (Dec.) 1960. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 7, 1962, pp. 290-293, CFSTI-TT-62-11103, U.S. Dept. of Commerce, Springfield, Va.

Sixteen Moscow city street traffic directing workers were examined for COHb blood concentration as described in the text. Results of analyses of 76 blood specimens showed a higher level of COHb blood content than in appropriately selected controls.

COHb blood concentration among the Moscow residing controls ranged between 0.0-6.0% in the summer and 0.0-12.0% in the fall; COHb concentration in the blood of Moscow traffic directing personnel ranged between 12.0-40.0%. - Authors' Conclusion

562. Von Oettingen, W.F.: Carbon Monoxide: Its Hazards and the Mechanism of its Action. Federal Security Agency, U.S. Public Health Service, PHSB No. 290. U.S. Government Printing Office, Washington, D. C., 1944, pp. 257.

Investigations by the author show that CO poisoning is characterized by the formation of CO hemoglobin and that the amount of CO hemoglobin formed depends upon the concentration of CO in the air, the duration of the exposure, and the rate of respiration of the individual exposed. An increase in the temperature, humidity, and CO_2 content of the air or a decrease in the concentration of O_2 will stimulate the respiration and hence favor the absorption of CO. But if such variations are eliminated, certain concentrations of CO in air will convert only a definite percentage of oxyhemoglobin into CO hemoglobin until an equilibrium is reached. The speed with which the maximal concentration is reached depends upon the concentration of CO in air, so that with high concentrations of CO maximal saturation may occur very rapidly.

CO may also react with other "heme"-containing pigments and enzymes, but, of all pigments mentioned, only the pseudohemoglobin has a greater affinity to CO than hemoglobin, and at present it appears impossible to judge on the physiological importance of this phenomenon. The question as to whether or not CO affects the functioning of other pigments such as myoglobin or cytochrome appears to need further study, and the same holds true regarding information on the effect of CO on certain pigments found in the brain.

Regarding the relation between toxic symptoms and the concentration of CO hemoglobin in the blood, it appears that concentrations below 20 percent cause only moderate subjective complaints and that these become serious with concentrations up to 30 percent and alarming with higher concentrations. It appears impossible to state which concentration of CO hemoglobin in the blood will be fatal because this will vary considerably with the type of exposure and the O_2 need of the organism at the time of the exposure, but it appears that concentrations between 60 and 80 percent will be dangerous to life.

Analysis of the clinical picture and the pathological findings in CO poisoning, especially in regard to the behavior of the circulatory apparatus and the central nervous system as well as the metabolism, appears to indicate that the sequelae of CO poisoning are more serious than would be expected from mere anoxemia of a similar degree. In spite of the impressive parallelism between the effects of CO poisoning and those produced by lack of O_2 it cannot be denied that there are a number of reactions and phenomena which may indicate a specific primary or secondary effect of CO on certain "heme"-containing pigments or enzymes of the organism. - Author's Conclusions Modified.

563. White, J.J.: Carbon monoxide and its relation to aircraft. U.S. Naval Med. Bull. 30:151-165 (April) 1932.

Carbon monoxide, a product of incomplete combustion, is present in the exhaust gas of all types of airplanes. In some types of planes, depending on type of exhaust leads, fuselage, etc., this gas is carried back to the cockpits of the plane in sufficient concentration to result in as much as 15 per cent saturation of the blood of the pilot and other occupants of the plane.

Although the highest saturation of blood obtained during the investigation (15 per cent) is not sufficient to render a person unconscious, or to be a direct cause of a crash, it is known that the absorption of even minute amounts of carbon monoxide is highly undesirable, due to the probable adverse effect on the efficiency of the pilot.

The fact that exposure to a low concentration over a long period is more harmful than a brief exposure to a very high concentration, increases the importance of eliminating all traces of carbon monoxide.

Comparatively simple and inexpensive modification of the exhaust leads has eliminated carbon monoxide from the area where it is absorbed by the pilot or other occupants of the plane. - Author's Sum.

564. Wilks, S.S., Tomashefski, J.F., and Clark, R.T., Jr.: Physiological effects of chronic exposure to carbon monoxide. J. Appl. Physiol. 14:305-310 (May) 1959.

A group of 7 dogs was given a daily 6-8 hour exposure to CO levels of 0.08 to 0.10% for a period of 36 weeks and their tolerance to CO was compared with that of normal dogs, altitude-acclimatized dogs, and dogs transfused with blood from normal dogs. The observed increased tolerance to CO was attributed primarily to the increase in concentration of the hemoglobin pigments in the blood. With this increased hemoglobin there was a greater reserve of the pigment for O_2 transport at a given concentration level of HbCO (carboxyhemoglobin). There was no evidence of factors, other than hematologic, which increased the tolerance of the dogs to CO. Animals subjected to other hypoxic stress such as altitude, or normal animals transfused with normal blood to increase the hematocrit level, showed increased tolerance similar to that accomplished by chronic exposure to low CO levels. - APCA 2643

564a Woodruff, R.S.: Carbon monoxide poisoning. Med. Sc. 7:550 (April 25) 1960.

At the Meeting of the Academy of Forensic Sciences held in Chicago in 1960, items of general medical interest were discussed. In discussing effects of CO poisoning before the Pathology Section, author presented:

> "evidence on the transmission of carbon monoxide across the placenta. A woman five-months pregnant died of asphyxiation by illuminating gas. Her blood showed a carbon monoxide saturation of 65%. Heart blood obtained from her fetus showed a carbon monoxide saturation of 40%. It is evident that carbon monoxide crosses the placenta readily."

565. Yant, W.P., Chornyak, J., Schrenk, H.H., Patty, F.A., and Sayers, R.R.: VI. Blood chemistry of dogs after comparatively rapid carbon-monoxide asphyxia. In: Studies in Asphyxia. U.S. Treasury Dept., PHS, PHB No. 211, 1934, pp. 61.

Among dogs exposed to atmospheres which were depleted of oxygen at a rate which caused a progressive asphyxial condition simulating asphyxia resulting from exposure to approximately 0.6 percent carbon monoxide in air by volume, there was a marked hyperglycemia and hyperuricemia.

The nonprotein nitrogen and urea increased slightly. The total and preformed creatinine remained practically normal; the inorganic phosphorus increased.

There was an increase in the hydrogen-ion concentration, and a marked decrease in the carbon-dioxide capacity of the plasma and the carbon-dioxide content of the blood.

The oxygen saturation of the arterial blood at death ranged from 1.3 to 8 percent.

The blood counts showed no marked abnormalities. - Authors' Sum.

566. Yarrow, T.J., Jr.: Chronic carbon monoxid poisoning and carbonyl hemoglobinuria: The latter a hitherto undescribed condition. Amer. Med. 4:338-343, 1902.

In April 1900, author called attention to chronic toxemia resulting from inhalation of small quantities of illuminating gas from leaky gas pipe fixtures. He emphasizes the point that chronic CO poisoning occurs more frequently than is thought possible and that it is responsible for many obscure conditions which often remain unsolved. Author advocates the extensive use of the spectroscope in diagnosis of such obscure conditions. Two cases of chronic CO poisoning are described. One is believed to be the first reporting carbonyl hemoglobinuria following or accompanying CO poisoning. - AGC

567. Zorn, H.: On the diagnosis of chronic CO poisoning. (German) Rass. Med. Indust. 33:325-329 (May-Aug.) 1964.

The author has the opportunity of observing a group of workmen who worked in noisy premises and were exposed to low concentrations of CO over a relatively long period on account of a leak of gas which had not been noticed. Examinations and psychological tests when compared to those previously made showed an increase in the excitability and irritability to noises. The percentage of carboxyhemoglobinemia varied between 10 and 20%. The electroencephalogram revealed a picture of extremely unstable frequency. When the leak had finally been found and stopped, the tests returned to normal after eight weeks in the young subjects and after 16 in the elderly and old. These observations led the author to advise a series of examinations and tests to be given to workmen at intervals of 3-4 years, so as to follow up the action of sub-toxic concentrations of CO. - Author's Sum.

Method of Detection

568. Arnold, H.R., Carrier, E.B., Smith, H.P., and Whipple, G.H.: Blood volume studies. V. The carbon monoxide method--its accuracy and limitations. Amer. J. Physiol. 56:313-327, 1921.

The carbon monoxide method gives a reasonably accurate measure of the body hemoglobin and hemoglobin volume. We use these terms to indicate the total body pigment substances which fix the inhaled CO and bring about its dilution in the circulating blood. It is obvious that the true red cell hemoglobin volume is slightly less than the total hemoglobin volume.

Repeated hemoglobin volume estimations on normal dogs give figures which are reasonably constant, allowing for certain expected physiological variations.

Hemoglobin volume estimations before and after unit hemorrhages give figures for the actual measured and indirectly calculated amounts which are in close accord.

In our opinion this method alone gives no accurate information concerning plasma volume.

Various controls of the several steps of this method, as used in our hands, are submitted. These controls establish this method as accurate at least within 5 per cent error. Further refinements and the use of packed red cells, especially in anemia, increase the accuracy of the method. - Authors' Sum.

569. Boor, A.K., and Bachem, A.: A spectrographic study of carbon monoxide hemoglobin. J. Biol. Chem. 85:743-749, 1930.

The transmission curve of carbon monoxide hemoglobin spectrum is shown.

Evidence of the purity of the carbon monoxide hemoglobin, made by the method described, is presented in Fig. 2. No difference is indicated between spectra of uncrystallized and crystallized carbon monoxide hemoglobin made by this method.

Spectra of carbon monoxide hemoglobin from different species are shown to be alike.

A water solution of oxyhemoglobin is shown to change upon standing; in time methemoglobin is formed, probably with another modification of oxyhemoglobin. Carbon monoxide hemoglobin seems very stable in this respect. - Authors' Sum.

570. Bowden, C.H., and Woodhall, W.R.: The determination and significance of low blood carboxyhaemoglobin levels. Med. Sc. Law. 4:98-107 (April) 1964.

The method described by Whitehead and Worthington (1961) for the determination of carboxyhaemoglobin has been examined and minor modifications are suggested. The sensitivity and spedificity of the method has been confirmed at low COHb saturations.

Forty-two non-smokers and 58 smokers were examined at various times of day using this technique. The mean COHb values obtained in the morning prior to smoking were 0.7 per cent for non-smokers and 1.5 per cent for smokers; the difference in means was highly significant. In the afternoon, smokers gave a mean value of 2.7 per cent. It is calculated that a saturation of 8 per cent COHb will be achieved "normally" by a smoker only in exceptional circumstances.

The significance of the results in relation to the reconstruction of fatal transportation accidents is briefly discussed. - Authors' Abst.

571. Chinn, H.I.: A Method for the Determination of Carbon Monoxide in Alveolar Air, Together with a Correlation of Values Thus Obtained with Carboxyhemoglobin Concentrations in Blood. Aviation Medicine Randolph AFB, Texas, April 5, 1944, 9 pp. DDC AD 135575

A simple method has been devised for the determination of carbon in alveolar air. An excellent correlation has been shown between the alveolar carbon monoxide content and the carboxyhemoglobin concentration in blood. This procedure possesses the following advantages: ease of operation, rapidity of analysis, omission of blood samples. use of untrained personnel, avoidance of all solutions, and compactness of apparatus. Its disadvantages lies in the necessity for subject co-operation so that determination cannot be made on unconscious or dead persons. Replacement of oxyhemoglobin by carboxyhemoglobin cannot be demonstrated by oximeter measurement. - Author's Abst.

572. Chinn, H.I., Pawel, N.E.R., and Redmond, R.F.: A Simple Micromethod for Blood Carbon Monoxide Determination. USAF School of Aviation Medicine, Randolph Field, Texas, July 1955, 4 pp. DDC AD 79985.

During World War II, Shepherd and coworkers at the National Bureau of Standards (7) developed indicating tubes for detection of minute quantities of CO in air. The remarkable specificity and sensitivity of these tubes suggested that they might be adapted to the rapid determination of CO in small quantities of blood. This report presents such a method, one in which finger blood can be analyzed by untrained personnel in the absence of laboratory facilities. - Authors' Introduction.

573. Christman, A.A., and Randall, E.L.: A convenient and accurate method for the determination and detection of carbon monoxide in blood. J. Biol. Chem. 102:595-609, 1933.

A simple and accurate method requiring inexpensive apparatus is described for the determination of carbon monoxide in blood. The method is based primarily on the fact that palladium chloride is reduced by carbon monoxide, and the excess of palladium chloride which is present is determined by a colorimetric procedure. - Authors' Sum.

574. Commins, B.T., and Lawther, P.J.: A sensitive method for the determination of carboxyhaemoglobin in a finger prick sample of blood. British J. Indust. Med. 22:139-143 (April) 1965.

About 0.01 ml. of blood taken from a finger prick is dissolved in 10 ml. of 0.04% ammonia solution. The solution is divided into two halves, and oxygen is bubbled through one half to convert any carboxyhaemoglobin into oxyhaemoglobin. The spectra of the two halves are then compared in a spectrophotometer, and the difference between them is used to estimate the carboxyhaemoglobin content of the blood either graphically or by calculation from a simple formula. Calibration is simple and need only be done once. A sample of blood can be analysed in about 20 minutes, which includes the time to collect the sample. The method is sensitive enough to be used for the analysis of solution of blood containing less than 1% carboxyhaemoglobin. - Authors' Abst.

575. Crosby, W.H., Munn, J.I., and Furth, F.W.: Standardizing a method for clinical hemoglobinometry. U.S. Armed Forces Med. J. 5:693-703, 1954.

Using the Coleman Jr. spectrophotometer and Drabkin's solution, a method of standardizing hemoglobinometry for clinical use is described. The procedure for standardization of the equipment involved is given in a detailed description of the methods of calibrating the instrument, selecting matched colorimeter curvettes, and calibrating the blood diluting pipettes. The method for clinical hemoglobinometry is outlined by a description of the preparation of Drabkin's solution, and of the method for hemoglobin determination with cyanmethemoglobin. - Authors' Sum.

576. Del Vecchio, V.: Determination of carbon monoxide in the air. Minerva med. (Turin) 49:1028-1048 (March 21) 1958.

Carbon monoxide is discussed as to nomenclature, physiochemical properties, toxicity, tolerable concentrations, and methods of measuring its concentration in the air. Some of the semi-analytical methods of measurement in the air are listed and discussed in detail. They fall into the 3 main groupings of: titrimetric, using pentose oxide; photometric, using palladium chloride; and a method measuring the level of carboxyhemoglobin, or COHb, in the blood. Some of the continuously or semi-continuously measuring methods are also discussed. Many schematic drawings and photographs of the testing equipment are included in the text, together with graphs showing the toxicity of CO as a function of concentration and of the period of time of exposure; the rate of saturation of hemoglobin with various concentrations of CO in the air; and the percentage of carboxyhemoglobin in the blood correlated with percentage of CO in the air, the period of exposure, and the activity of the subject. - APCA 2823

577. Douglas, T.A.: The Determination of Carbon Monoxide in Blood. Ann. Occupat. Hyg. (London) 5:211-216 (Oct.-Dec.) 1962.

The estimation of carboxyhemoglobin has been attempted by numerous methods, some extremely simple and others rather complex. The fact that so many methods of estimating carboxyhemoglobin have been described would tend to indicate that no ideal and simple method is available. In some cases all that is required is a qualitative examination for the presence of carboxyhemoglobin and no accurate estimate is required of the concentration. In other cases, a quantitative analysis is desired. This latter presents difficulties since, although it is not difficult to estimate carboxyhemoglobin in higher concentrations in blood, at the lower end of the scale considerable discrepancies are encountered. Three different tests which are subjective (based on the operator's ability to match color visibly) are those of the Haldane method, the alkali test, and the tannin test. In addition to the manometric method, other methods (based primarily on chemical procedures) are ones using palladium chloride, heat precipitation, inability of dithionite to reduce carboxyhemoglobin, using the Hartridge reversion spectroscope, and several other methods using the spectrophotometer. In a continuing experiment on carboxyhemoglobin, content of the blood of dogs, the author was searching for a method of determination which would be accurate, rapid, and simple. Comparison of results were made between the modified manometric method of VanSlyke and Neil--which has appeared to be the most reliable and was used as the standard, and 2 other methods. The Heilmeyer spectrophotometric method was simple and required little time; the method currently in use is the Harrison method using the reversion spectroscope. When values between 80 and 60% COHb were estimated, the Heilmeyer method agreed well with the VanSlyke but the Harrison method tended to be a little low. When values between 60 and 30% COHb were selected, the Harrison method was better whereas the Heilmeyer tended to be low. At levels below 30% COHb, the Harrison method was unreliable but the Heilmeyer method stood comparison with the VanSlyke method. It was concluded that, with suitable care being taken in the wavelength setting of the spectrophotometer, the Heilmeyer method could be a useful method of estimating. COHb. - APCA 5251

578. Drabkin, D.L.: The standardization of hemoglobin measurement. Amer. J. Med. Sc. 215:110-111 (Jan.) 1948.

Author states that in his work on the standardization of hemoglobin, it had proved desirable to find an independent (non-hemoglobin or hemin derivative) instead for the standardization of hemoglobin measurement, as well as instruments used for this purpose. Standards applicable to the use of photoelectric filter photometers seemed to be also advisable.

Drabkin and Austin's spectrophotometric standards of cupric ammonium sulfate ($CuSO_4$ in 2N NH_4OH) successfully adopted for the standardization of hemoglobin measurement, and the Evelyn or Klett-Summerson filter photometer calibrated for hemoglobin measurement by means of the gravimetrically prepared independent standard of $CuSO_4, 4NH_2, H_2O$, are discussed in this short paper. - AGC

579. Drabkin, D.L : The standardization of hemoglobin measurement. Amer. J. Med. Sc. 217:710-711 (June) 1949.

A simplified, reliable procedure for the standardization of hemoglobin measurement, with hemoglobin iron as the final basis of reference is described in this paper. It has been established that the spectrophotometric or photometric determination of cyanmethemoglobin, MHbCN, is the most direct analysis available for total hemin or hemoglobin iron.

The method for circumventing tiresome and exacting standardization procedures in the calibration of commonly used photoelectric filter photometers for the accurate measurement of hemoglobin concentration is described in detail.

For the calibration of instruments for hemoglobin measurement, the copper solution and calibrated glass serve as desirable instrumental performance standards, and are described in this short paper. - AGC

580. Frederick, R.C.: Carbon monoxide poisoning: Its detection, and the determination of percentage saturation in blood, by means of the Hartridge Reversion Spectroscope. Analyst 56:561-568 (Sept.) 1931.

The history of CO poisoning is briefly reviewed. Physiological responses to various concentrations of CO as studied and summarized by earlier investigators are shown in tables. The application of the Hartridge Reversion Spectroscope which is a reliable tool for the detection of small amounts of CO in the blood is described in detail. - AGC

581. Furlong, N.B.: A Disposable Analyzer for Semiquantitative Determination of Carbon Monoxide in Blood. Aerospace Med. Res. Lab., Wright-Patterson AFB, Ohio, Sept. 1957, 5 pp. DDC AD 142013.

A disposable blood-carbon monoxide analyzer with which it is possible to make relatively accurate measurements has been developed. Use of this device requires no additional apparatus or training. The analyzer is described; and the method of operation is presented. - Author's Abst.

582. Gaensler, E.A., Cadigan, J.B., Jr., Ellicott, M.F., Jones, R.H., and Marks, A.: A new method for rapid precise determination of carbon monoxide in blood. J. Lab. & Clin. Med. 49:945-957 (June) 1957.

A simple, rapid, highly accurate method is described for determination of carbon monoxide content of blood. The chamber of the manometric Van Slyke apparatus is used for decomposition and vacuum extraction. The gas is diluted in a tonometer and analyzed for CO content with an infrared meter of great specificity and good stability, which has been modified for highest accuracy.

Theoretically, readings to 0.0025 ml. per 100 ml. CO content are possible with a 3 ml. blood sample. In practice, the S.D. of the variance of 50 paired observations was 0.023 ml. per 100 ml. and the coefficient of variation was 2.1 per cent.

The error due to the presence of CO_2 in the extracted gas was shown to be within the limit of accuracy of the technique. At low concentrations of CO, results were the same whether acid ferricyanide or sulfuric acid was used for conversion to methemoglobin; with higher CO concentrations, sulfuric acid led to incomplete decomposition. Saponin should not be used because it contains traces of CO. Blank determinations were shown to be unnecessary. Cold storage of blood up to 24 hours and slight exposure to air of the sample did not affect the results.

Results by this method were compared to those obtained by more conventional techniques.

A number of applications are illustrated including assessment of smoking habits, the COHb saturation during CO breathing, the CO-Hb equilibration time and dissociation curve, and determination of "true blood volume." - Authors' Sum.

583. Giacomo, P., Guillot, M., and Jacquinot, P.: An automatic and instantaneous method of determining carbon monoxide in blood. Compt. rend. 243:985-987, 1956.

A method is described whereby low or high carbon monoxide in the blood can be determined on one drop of blood in a few seconds within ± 0.5% by projecting and registering the absorption spectra on a photographic film, and the maximum can be determined by a registering microphotometer. - AGC

584. Gonzales, T.A., Vance, M., Helpern, M., and Umberger, C.J.: Legal Medicine, Pathology and Toxicology (1345 pp.) 2nd edition 1954. Appleton-Century-Crafts, Inc., pp. 956-960.

In chapter 42, Gaseous Poisons, there is a section on methods of sampling and analysis of blood for CO content. The alkali dilution test is named as a quick probing test indicating a concentration of more than 10% carboxyhemoglobin in blood.

Procedure and analysis of a simple and rapid method, the quantitative estimation of CO in blood by reduction of palladium chloride to palladium, is described in detail. The Van Slyke monometric method is considered to be the most accurate method for the determination of CO in blood. An analysis of air for CO has been compiled from the files of New York City Board of Health, showing the possible effects of exposure to low concentrations of CO in the atmosphere. - AGC

585. Gramer, L.: On problems connected with methods for the determination of carbon monoxide in the blood (Comparative Studies). Zentr. Arbeitsmed. U. Arbeitsschutz 11:53-59 (March) 1961.

The author made a comparative study of methods of determination of carbon monoxide in the blood, discussing some of the possibilities and limitations of the several methods. The methods were limited to those using simple laboratory equipment and to those which were quantitative rather than qualitative. The Wolff test was the routine method used. At a fixed pH level, the blood was warmed causing the hemoglobin to coagulate while the carboxyhemoglobin CO-Hb remained in solution. After filtration, the resulting more or less intense red color of the filtrate was checked by photometer methods for content of CO-Hb depending on the degree of obstruction of light. Many studies were made to determine the effects of such factors as pH, temperature, time, and type of filter paper on the results. Several charts and curves in the text indicate that the best results were obtained at a pH range of 4.98-5.08, with heating at 55°C. for 5 minutes. A relatively hard-surfaced filter paper should be used throughout the testing. Micro-gasanalyses were done on the same blood samples using the method of Roughton and Scholander, after the blood pH had been adjusted in the presence of acetate buffer to a pH of 4.52-6.0. The Roughton and Scholander method was noted as being not only more accurate but also as needing for the test only 0.04 cm.3 of blood (as against 0.25 cm.^{3} for the Wolff test) and for being a method of detecting traces only of CO. The studies with the Gettler and Freimuth test were not as successful. The method depended on the reduction of $PdCl_2$, with which the filter paper was impregnated, to metallic palladium and the formation of a black-precipitate on the filter paper by reaction with the CO when the blood is filtered. Blood samples were used of 0.5-5.0 cm.3. Despite many attempts to improve the results, it was felt that tests by this method were not conclusive. The method of Grosskopf and Sachs was a very simple and fast one, involving the freeing of the gas following treatment with potassium ferricyanide and lactic acid, but was semi-quantitative only. It was concluded that there is no 1 test which is wholly adequate and that a diagnosis should not be given unless based on the results of 2 or more test methods. - APCA 4423

586. Haldane, J.: A method of detecting and estimating carbonic oxide in air. J. Physiol. 18:463-469, 1895.

In view of the very poisonous nature of carbonic oxide, and the comparative frequency with which cases of poisoning by this gas occur, much attention has been given to its detection and estimation. No satisfactory method has hitherto been described, however, for determining very small, but still more or less poisonous, percentages of carbonic oxide in air. There is special difficulty when, as almost always happens, marsh-gas or other hydrocarbons are present along with the carbonic oxide.

The method described in this paper is very simple, and depends on the fact that when a haemoglobin solution is well shaken with air containing carbonic oxide the proportion of the haemoglobin, which finally combines with the carbonic oxide, varies with the percentages of carbonic oxide present in the air. By determining colorimetrically the proportion of the haemoglobin which has combined with the carbonic oxide it is thus possible to infer the percentage of carbonic oxide present in the air.

587. Henderson, M., and Apthorp, G.H.: A rapid method for the estimation of carbon monoxide in blood. British Med. J. No. 5216:1853-1854 (Dec. 24) 1960.

Using the Sjöstrand rebreathing system (Acta Physiol. Scand. (Stockholm) 16:201, 1948), a rapid method for the estimation of the percentage of carboxy hemoglobin in the blood, is described. The results are compared with those from a direct blood analysis. The modified rebreathing method gave results which compared well with the direct method. Evidence is given which suggests that for routine work an assumed oxygen value can be used in Dahlstrom's equation. - APCA 3835

588. Lawther, P.J., and Apthorp, G.H.: A method for the determination of carbon monoxide in blood. British J. Indust. Med. 12:326, 1955.

The purpose of this paper is to describe a method for the determination of carbon monoxide in blood which is both simple and accurate. The procedure is similar to that used for the determination of nitrous oxide in blood described by Lawther and Bates (1953). The blood gases are extracted under vacuum after reduction of the haemoglobin by acid ferricyanide and are analysed by infra-red absorption. Other blood gases do not interfere with the estimation. - Authors' Abst.

589. Leclerc, E.: Detection of carbon monoxide. Rev. univ. mines 11: 310, 1946.

Among the methods of detecting carbon monoxide described are the blood method, the use of silver salts (which are reduced by the gas), of palladium or gold chloride (which are reduced to the metal), methods of catalytic combustion, and the iodine pentoxide detector. - BMB 1500

590. Letourneau, L.S.: The laboratory detection of carbon monoxide poisoning. Amer. J. Med. Technol. 25:175-178 (May-June) 1959.

The chemistry of carbon monoxide poisoning is primarily the chemistry of the combination of carbon monoxide gas with the respiratory pigment, hemoglobin. Relatively low concentrations of this gas inhibit the oxygen uptake in the lungs. However, carboxyhemoglobin must reach rather high concentrations--generally in the order of 50% or more of the total hemoglobin in non-anemic persons, in order to cause death. The author discusses some of the physical chemistry of carbon monoxide poisoning and presents some simple chemical and spectroscopic methods for the detection of carboxyhemoglobin. - APCA 2564.

591. Mayer, J.: A Screening Semi-Quantitative Method for the Determination of Carbon Monoxide in Blood. Aerospace Med. Res. Lab., Wright-Patterson AFB, Ohio, April, 1956, 19 pp. DDC AD 93165.

A simple diffusion technique is presented for the determination of carbon monoxide in blood. Statistical evaluation of the data derived from quantitative estimation of the carboxyhemoglobin by matching the unknown reaction with a standard chart proves the definite reliability of this procedure. - Author's Abst.

592. Millikan, G.A.: The oximeter, an instrument for measuring continuously the oxygen saturation of arterial blood in man. Rev. Sc. Inst. 13: 434-444, 1942.

The oxygen saturation of arterial blood in man can be measured continuously in situ by means of bichromatic photoelectric colorimetry of the intact fully flushed ear. The accuracy of the device as determined by gas analysis of arterial blood samples is from 3 to 8 percent. The entire optical and photoelectric system, comprising a miniature lamp bulb, two color filters, and two selenium barrier-layer photo-cells, weighs 30 grams, and slips over the shell of the ear. One of the color filters transmits a wave-length band which is equally absorbed by oxy- and reduced hemoglobin, thus providing a means of measuring the amount of total hemoglobin in the optical path, independent of its degree of oxygen saturation. The other color is very differently absorbed by the two hemoglobin forms. Several direct reading forms of the instrument are discussed. - Author's Abst.

593. Ringold, A., Goldsmith, J.R., Helwig, H.L., Finn, R., and Schiette, F.: Estimating recent carbon monoxide exposures. A rapid method. Arch. Environ. Health 5:308-318 (Oct.) 1962.

A valid method for determining the carboxyhemoglobin level in the body has been developed. The method is based on the 20-second breath-holding method first described by Jones et al., using an infrared analyser first reported by Lawther and Apthrop. Our work shows that a polyvinyl bag can be used for collection of samples in the field.

An application of this method is reported. This confirms the fact that cigarette smoking is a major factor in determining the carboxyhemoglobin level in a population. Pipe and cigar smokers appear not to have much increase in carboxyhemoglobin.

The method should be suitable for studying the relationship of carboxyhemoglobin to occupational and to ambient air pollution exposures. - Authors' Sum. & APCA 5047

594. Rothschild, J.E.: Carbon monoxide poisoning. Amer. Pract. 13: 213-218 (March) 1962.

In reviewing literature, author discusses the overall effect of CO on the health of man. He also reports a case of acute CO poisoning in which he used exchange transfusion to treat the victim. - AGC

595. Roughton, F.J.W.: The kinetics of hemoglobin IV--General methods and theoretical basis for the reaction with carbon monoxide. Proc.Royal Soc. (Series B) 115:451-464, 1934.

The rapid reaction velocity method of Haftridge and Roughton has been applied to the following reaction--(a) the combination of CO with reduced hemoglobin (Hb); (b) the displacement of O_2 form combination with Hb by CO; (c) the displacement of CO from combination with Hb by O_2.

General descriptions of the experimental technique are given, and the importance, theoretical and practical, of such measurements is emphasized.

The oxgen-hemoglobin reaction is briefly reviewed from the physico-chemical standpoint, with a view to the theoretical consideration of the carbon monoxide reactions.

Under certain conditions it is shown that the equation for the velocity of reaction (a) is identical on the Hüfner theory and on the intermediate compound hypothesis of Adair, but is quite different on the basis of Hill's equation.

These deductions are experimentally tested in Part V; the issue is favorable to the Adair hypothesis and not to the Hill theory.

Reactions (b) and (c) follow very simple equations both as regards their equilibrium point and their velocities. This is also difficult to reconcile with the Hill equation; it can, however, be brought into line with the Adair hypothesis, if the competition of CO and O_2 for combination with Hb obeys the same principles as those postulated (in simple cases) by Langmuir for the reactions between gases and heated metallic surfaces. -Author's Sum.

596. Roughton, F.J.W., and Root, W.S.: The estimation of small amounts of carbon monoxide in blood. J. Biol. Chem. 160:123-133, 1945.

A combination of Horvath and Roughton's modified Van Slyke method with the syringe-capillary technique of Scholander and Roughton is described. With this procedure the CO content of 0.5 cc. blood samples can be determined to within 0.02 volume per cent over the range 0 to 2 volumes per cent, and to within 0.03 volume per cent over the range 2.0 to 5.0 volumes per cent. The method is thus specially applicable to blood volume determinations on small animals, and is also of value in the high range of CO saturation, wherein the maximum accuracy of the Van Slyke technique is readily obtained. - Authors' Sum.

597. Sayers, R.R., and Yant, W.P.: Dangers of and Treatment for Carbon Monoxide Poisoning. U.S. BMRI No. 2476, May 1923, 11 pp.

Properties, chemical and physiological action of CO are discussed. Approximate percentage of CO found in gases from various sources of poisoning are given. Methods of detection by odor, blood methods, detection by tests on small animals, and the Hoolamite detection are described. Time required for various concentrations of CO to procure 80% of equilibrium value of blood saturation are listed, and symptoms caused by various percentages of CO in the blood are described in relationship to percentage of blood saturation. - AGC

598. Sayers, R.R., O'Brien, H.R., Jones, G.W., and Yant, W.P.: Collection and preservation of blood samples for determination of carbon monoxide. Pub. Health Rep. 38:2005-2011 (Aug. 31) 1923.

A modified Keidel tube method, by which 10 to 15 c.c. of blood may be collected in the field, shipped to a central laboratory, and kept with slight chances of clotting or change in carbon monoxide content has been described. If such a tube is not available, a small vial, well stoppered with a cork, will serve satisfactorily.

Sodium or potassium oxalate (0.2 per cent), sodium fluoride (0.3 per cent), and sodium citrate (0.4 to 0.8 per cent) inhibit coagulation, the last-named being the least efficient. Oxalate causes some change in the blood, with a slight altering of the carbon monoxide content. The fluoride is recommended because it is not open to these objections.

No change in the amount of carbon monoxide in the blood has been detected from standing when 0.3 per cent sodium fluoride is used. - Authors' Sum.

599. Sayers, R.R., and Yant, W.P.: The elimination of carbon monoxide from blood, by treatment with air, with oxygen, and with a mixture of carbon dioxide and oxygen. Pub. Health Rep. 38:2053-2074 (Sept. 7) 1923.

Recovery from carbon-monoxide poisoning depends to a great extent upon early elimination of carbon monoxide from the blood.

The rate of elimination of carbon monoxide from the blood depends upon the percentage of oxygen in the air breathed, also upon the rate and depth of respiration.

Pure oxygen causes the elimination of carbon monoxide about four times as fast as normal air, when breathed by persons who have been gassed until 35 or 40 per cent of the hemoglobin in their blood has been combined with carbon monoxide.

Breathing a mixture of oxygen containing 8 to 10 per cent of carbon dioxide causes deep and rapid respiration.

Breathing a mixture of oxygen and carbon dioxide (8 to 10 per cent) causes the elimination of carbon monoxide about five to six times as fast as normal air, when breathed by persons who have been gassed until 30 to 40 per cent of their blood has been combined with carbon monoxide.

It is recommended that all victims not under a physician's care be caused to breathe oxygen in the purest form available for at least 20 to 45 minutes.

It is recommended that physicians use the carbon dioxide-oxygen mixture where possible, and note the results, but when this mixture is not available that they use pure oxygen. - Authors' Sum.

600. Sayers, R.R., Yant, W.P., and Jones, G.W.: The pyro-tannic acid method for the quantitative determination of carbon monoxide in blood and air. Pub. Health Rep. 38:2311-2320 (Oct. 5) 1923.

A durable and compact laboratory or field apparatus for the quantitative determination of carbon monoxide in blood and air has been described. On account of the compactness, durability, and ease with which accurate and dependable results can be obtained, it should be of great use in investigations pertaining to the cause, diagnosis, and treatment of carbon-monoxide poisoning.

The percentage saturation of CO in blood can easily be determined to a degree of accuracy involving only 5 per cent error.

The actual error of the method for determination of CO in air, even when used by inexperienced men, was found to be 0.005 in regions of 0.000 to 0.05 per cent CO; 0.01 in regions of 0.05 to 0.08 per cent; 0.02 in regions of 0.08 to 0.12 per cent; and 0.03 in regions of 0.12 to 0.18 per cent carbon monoxide. - Authors' Sum.

601. **Sayers, R.R., and Yant, W.P.: The Pyrotannic Acid Method for the Quantitative Determination of Carbon Monoxide in Blood and in Air. Its Use in the Diagnosis and Investigation of Cases of Carbon Monoxide Poisoning. U.S. Dept. Commerce, BMTP 373, 1925, 18 pp.**

A method found to be satisfactory for quantitative analysis of CO in blood and air cases of CO poisoning is outlined.

A compact field apparatus is described. Owing to its durability, and the ease with which accurate and dependable results can be obtained, it should be of great use in investigations pertaining to the cause, diagnosis, and treatment of CO poisoning. - Authors' Sum.

602. Scholander, P.F., and Roughton, F.J.W.: A simple micro-gasometric method of estimating carbon monoxide in blood. J. Indust. Hyg. 24: 218-221, 1942.

This paper describes a convenient micro gasometric method for estimating the CO content of a finger prick sample of blood (40 cu. mm.) in 6-10 minutes. Apart from a special but simple glass syringe capillary apparatus, only easily prepared solutions, ordinary syringes and beakers are required. The method is therefore available in any sheltered space without need for refined laboratory facilities. The accuracy is about 0.2 volumes per cent of CO or 1% COHb. - Authors' Sum.

603. Scholander, P.F., and Roughton, F.J.W.: Micro gasometric estimation of the blood gases. J. Biol. Chem. 148:551-563, 1943.

Three applications of syringe technique to the microdetermination of CO in blood are discussed in this paper: (a) a general method for saturations ranging from 0 to 100 per cent COHb, (b) a method for combined determinations of O_2 and CO on one sample of blood, (c) a special method precise enough for blood volume determination in which the CO content is kept below 2 volumes per cent.

The improvements are described in the original syringe-capillary procedure of Scholander and Roughton for the micro gasometric determination of CO in blood. With the new technique the usual corrections are necessary for temperature, aqueous vapor pressure, and barometric pressure. With blood samples of 40 c.mm., the accuracy of a single determination is 0.15 to 0.20 volume per cent. With blood samples of 120 c.mm. and a modified technique the accuracy is increased to 0.03 to 0.05 volume per cent and the method is therefore very suitable for blood volume determinations by the carbon monoxide method. A technique for the combined determination of O_2 and CO in a single 40 c.mm. sample of blood is also given. - Authors' Sum. Modified

604. Schrenk, H.H.: Results of laboratory tests. Determination of concentration of carbon monoxide in blood. Federal Security Agency, U.S. PHSB No. 278, 1942, Washington, D. C., pp. 36-57.

The levels of carbon monoxide found in the blood of traffic officers stationed in the Holland Tunnel during a period of two hours fall within the range of blood carbon monoxide concentration values observed in cigarette smokers with no occupational exposure to carbon monoxide. Amounts of carbon monoxide absorbed during tunnel duty appear to be added to amounts absorbed as a result of smoking. No complaints of ill health attributable to carbon monoxide exposure were made by these men. On the basis of earlier work, none was to be expected.

In the section "Other exposures to CO," author summarizes the results of the recent survey made and of the data presented in the literature. It appears that in most workplaces where there is reason to suspect that CO escapes into the breathing zone of the workers, the CO concentration usually remains below 1.0 part per 10,000 (100 p.p.m.). The commonest source of greater exposure than this is the operation of gasoline engines in an unventilated or a poorly ventilated room. - Author's Sum.

605. Sendroy, J., Jr., Liu, S.H., and Van Slyke, D.D.: The gasometric estimation of the relative affinity constant for carbon monoxide and oxygen in whole blood at 38°. Amer. J. Physiol. 90:511, 1929.

In the course of an investigation of the arterial blood oxygen tension in man, the carbon monoxide method of Haldane and Smith was used. This method involves the law finally formulated by Douglas, Haldane and Haldane, expressed mathematically by the equation

$$\frac{[HbCO]}{[HbO_2]} = K \frac{pCO}{pO_2}$$

where the brackets indicate concentrations of hemoglobin in union with gas, pCO and pO_2 the gas tensions, and K the relative affinity constant for hemoglobin for the two gases.

Undiluted, hemolyzed ox blood and human blood were saturated with various gas mixtures until equilibrium was attained. Two methods of saturation were employed, one a closed system, the other open to the atmosphere. The CO hemoglobin and oxyhemoglobin were estimated gasometrically according to Van Slyke and Neill and Van Slyke and Robscheit-Robbins. Oxygen tension was obtained by analysis. CO tension was accurately made up and the result calculated.

Up to the present time, three normal and three pathological bloods studied indicate for thirteen separate experiments, an average value of 210 for K. Fifteen experiments on ten different ox bloods give an average value of 179 for K. These values are tentative, subject to a correction, which would not change the order of magnitude. All results are within ± 2.5 per cent of the average. We have so far found no individual variation within the species in K for either ox blood or human blood, exceeding the limit of experimental error. - Authors' Abst.

606. Sendroy, J., Jr., and Liu, S.H.: Gasometric determination of oxygen and carbon monoxide in blood. J. Biol. Chem. 89:133-152, 1930.

An improved technique is described for the determination of oxygen and carbon monoxide in a single blood sample by the use of the Van Slyke-Neill manometric apparatus. The mixture of O_2 + CO + N_2 extracted from blood is removed to a micro-Hempel pipette, where the O_2 is absorbed, by a technique similar to that employed previously for manometric determination of amino nitrogen. The extraction chamber is then washed free of blood and the gases are returned for completion of the analysis. The procedure equals in accuracy the Van Slyke-Robscheit-Robbins method, is less laborious, and can be carried through in 25 to 30 minutes. - From text-AGC

606a. Sendroy, J., Jr.: Manometric analysis of gas mixtures. VI. Carbon monoxide by absorption with blood. J. Biolog. Chem. 95:599-611, 1932.

A method is described, whereby air containing carbon monoxide in concentrations from 0.05 to 0.3 per cent may conveniently be analyzed in the Van Slyke-Neill apparatus. The CO is first combined, in the chamber of the apparatus, with the hemoglobin of completely reduced blood, and the CO content of the blood is then determined by the method of Sendroy and Liu. - Author's Sum.

607. Siösteen, S.M., and Sjöstrand, T.: A method for determination of low concentrations of carbon monoxide in the blood and the relation between the CO-concentration in the blood and that in the alveolar air. Acta Physiol. Scandinav. 22:129-136, 1951.

A new method for determination of carbon monoxide in blood is described. Briefly, it consists of releasing the carbon monoxide by forming methemoglobin and mixing it with a known volume of oxygen. The CO concentration is then determined with the Lindelöv-Sjöstrand CO-meter.

The method makes it possible to measure a concentration of carbon monoxide as low as 0.005 volumes % in a blood sample of 20 ml. With a normal relative hemoglobin this corresponds to 0.02% of the saturation value. The accuracy, with double determinations, has been shown to be ± 6.5% at COHb levels of 0.5-2.0%. At higher COHb concentrations it is about ± 2.5% of the value. With relatively high COHb concentrations the carbon monoxide can be determined in blood samples of 0.2-1.0 ml.

A comparison has been made between the CO concentration in the blood and that in the alveolar air. An apparently linear relationship between the two values has been found within the concentration limits of 0.5 and 10% COHb. The CO levels in the blood and the corresponding ones in the alveolar air are significantly higher than the concentration in ordinary atmospheric or room air. - Authors' Sum.

608. **Sjöstrand, T.: A method for the determination of carboxy-haemoglobin concentrations by analysis of the alveolar air. Acta Physiol. Scandinav. 16:201-210, 1948.**

A method for the determination of the COHb-concentration in the blood by using the analysis of the CO-concentration in the alveolar air is described. An analytical apparatus for the measurement of low concentrations such as 0.0005% CO in the air, was constructed for the purpose and a short description is given. The alveolar air was obtained by collecting either the exhaled air and rebreathing this 10 times, or by expiring the nitrogen from the lungs and breathing pure oxygen together with the absorption of carbon dioxide until equilibrium is reached between the air in the sample and in the lungs. The first and simpler method has getting alveolar air samples for an error of about ± 3%. The latter method is even more accurate. A comparison of the accuracy of the method on different individuals shows a calculated error below ± 10% of the value. The usefulness of the method is discussed. - Author's Sum.

609. Sjöstrand, T.: The in vitro formation of carbon monoxide in blood. Acta Physiol. Scandinav. 24:314-332, 1951.

Earlier observations of an endogenous formation of carbon monoxide in man have been analysed with reference to the possibility that the carbon monoxide is formed in the blood by the breakdown of haemoglobin. The following results were obtained.

The COHb concentration of blood calculated from determinations of the CO pressure in alveolar air, agrees with the COHb concentration determined directly from blood. The partial pressure of carbon monoxide in the alveolar air is, however, considerably greater than that of ordinary atmospheric air, which means that carbon monoxide is constantly exhaled during respiration.

If blood is incubated at 38° C for 20-24 hours, an increase of 40-165% can be shown in the COHb concentration, this increase being particularly pronounced after haemolysis. This apparent formation of carbon monoxide in blood is considerably increased at acid or alkaline pH's or by addition of sodium azide.

If the blood is shaken with carbon monoxide before incubation at 38° C, the carboxyhaemoglobin concentration after 20 hours is decreased. If sodium azide is added to samples containing 5-30% COHb before incubation, the concentration is however increased, and at higher COHb-concentrations there is a decrease less than that observed without azide.

The formation of carbon monoxide was found to parallel the spontaneous formation of methaemoglobin on alteration of the pH or addition of sodium azide.

Addition of ascorbic acid and hydrogen peroxide greatly increases the CO formation. The amount of CO produced corresponds to a conversion of up to 15 per cent of the haemoglobin to COHb, calculated from the original haemoglobin concentrations.

The formation of CO seems to be parallel to the breakdown of haemoglobin to choleglobin (verdoglobin). This observation can be explained by the assumption that the opening of the tetrapyrrole ring occurs with the liberation of the a-C atom after oxidation to CO.

It was possible to demonstrate in one subject that the amounts of CO produced and haemoglobin decomposed bear a quantitative relation of approximately 1 molecule CO:1 haemin group. - Author's Sum.

610. Sjöstrand, T.: The formation of carbon monoxide by in vitro decomposition of haemoglobin in bile pigments. Acta Physiol. Scandinav. 26:328-333, 1952.

Solutions of crystalline horse haemoglobin were incubated at 38° C after the addition of ascorbic acid. It was possible to show the formation of CO constantly in conjunction with the appearance of an absorption band at wave length 630 mμ corresponding to the choleglobin (verdoglobin) band.

A linear relation exists between the amounts of CO and choleglobin formed during incubation up to about 24 hours.

When incubation is carried on for a longer time, the CO formation continues in linear relation to the time of incubation up to approximately 200 hours. At this point the absorption band of the haemoglobin has practically disappeared.

The maximal amount of CO obtained during incubation for longer periods corresponds to the CO-binding capacity of the initial haemoglobin solution.

These observations are in agreement with the previously expounded hypothesis that a molecule of CO is liberated when each of the porphyrin rings in the haemoglobin molecule splits. - Author's Sum.

611. Sjöstrand, T.: Formation of carbon monoxide by coupled oxidation of myoglobin with ascorbic acid. Acta Physiol. Scandinav. 26:334-337, 1952.

Solutions of myoglobin have been incubated at 38° C after the addition of ascorbid acid. Consequently there is a manifestation of carbon monoxide and a substance with an absorption band at 640 mμ. The observation coincides with previous observations of the decomposition of haemoglobin, and indicates that myoglobin can decompose in a manner similar to haemoglobin by oxidation of a methene group to CO, which splits. It may be supposed that this reaction also takes place in vivo and contributes to the endogenous formation of carbon monoxide. - Author's Sum.

612. Sjöstrand, T.: The formation of carbon monoxide by the decomposition of haemoglobin in vivo. Acta Physiol. Scandinav. 26:338-344, 1952.

Haemolysed blood and solutions of haemoglobin were injected into dogs intramuscularly, and into human beings and rabbits intravenously in connection with repeated determinations of the alveolar CO concentration or the concentration of CO in exhaled air. From the concentration and volume of CO in expired air, the volume of CO exhaled per minute was determined for a period of 5 to 8 hours after the injection.

It transpired from this that the injection of haemoglobin or haemolysed blood causes an increase in the alveolar CO concentration and the volume of CO exhaled per minute.

The quantitative relation between the increase in CO formation and the amount of haemoglobin that was injected, corresponds to the formation of 4 molecules of CO for each molecule of haemoglobin.

The observations agree with the supposition that a molecule of CO is formed during the splitting of haemochromogen's tetrapyrrole ring. It would seem that the endogenous formation of CO and its variations under normal and pathologic conditions can be explained in this way. - Author's Sum.

613. Stevens, A.M.: Carbon monoxide poisoning. Gradual, cumulative effects in young children, with report of a fatal case. J. A.M.A. 86:1201-1204 (April 17) 1926.

There is a seasonal increase, in the winter, of the hazard of gas poisoning, acute and chronic.

There is a cumulative poisonous effect of repeated or continuous exposure to small amounts of carbon monoxide.

Young children and infants are peculiarly susceptible to gradual carbon monoxide poisoning.

In serious cases of gradual gas poisoning, there will probably be more than 10 per cent of carbon monoxide in the blood.

There is a simple and raped qualitative test for carbon monoxide in the blood, which will show the presence of 10 per cent or more.

Clinicians should be on the alert to recognize cases of gradual poisoning by carbon monoxide, especially in infants. - Author's Sum.

614. Van Slyke, D.D., and Salvesen, H.A.: The determination of carbon monoxide in blood. J. Biol. Chem. 40:103-107, 1919.

A method is described for the determination of carbon monoxide in blood, the technique of which is exactly the same as that previously described by Van Slyke for the determination of oxygen, except that after the gases are extracted the oxygen is absorbed in the apparatus by introducing alkaline pyrogallate solution. The carbon monoxide remains and is measured directly at atmospheric pressure. - Authors' Sum.

615. Van Slyke, D.D., and Robscheit-Robbins, F.S.: The gasometric determination of small amounts of carbon monoxide in blood, and its application to blood volume studies. J. Biol. Chem. 72:39-50, 1927.

This paper presents a development of the blood carbon monoxide methods of Van Slyke and Salvesen and of Harington and Van Slyke with attention to certain details which reduce the error to 0.02 or 0.03 volumes percent. A technique is describe for quantitative gasometric determination of small amounts of carbon monoxide in blood. The present procedure was developed primarily to make possible the determination of blood volumes by the carbon monoxide method of Grehant and Quinquaud without saturating, as has previously been necessary, as much as one-third of the blood hemoglobin with CO in order to obtain accurate results. A technique requiring the saturation of only one-tenth to one-twentieth of the circulating hemoglobin makes the method more safe and convenient for use with human subjects, and with animals permits the introduction of CO by intravenous injection of CO-saturated blood instead of by inhalation of the gas. It appears that 4 minutes after injecting carbon monoxide blood as described in this paper one can estimate the volume of the circulating red cells from the blood CO content with less than 5 per cent error due to analytical technique and CO distribution within the blood. We have not ascertaine the magnitude of the possible additional error due to diffusion of CO from blood to tissue hemoglobin. - Authors' Sum. Modified.

616. Van Slyke, D.D., Hiller, A., Weisiger, J.R., and Cruz, W.O.: Determination of carbon monoxide in blood and of total and active hemoglobin by carbon monoxide capacity. Inactive hemoglobin and methemoglobin contents of normal human blood. J. Biol. Chem. 166:121-148, 1946.

Improved techniques for determining blood carbon monoxide and total hemoglobin, active hemoglobin, and inactive hemoglobin by the carbon monoxide capacity procedures are described.

In a series of nineteen freshly drawn normal human bloods inactive hemoglobin by the carbon monoxide method has been compared with methemoglobin determined by the cyanide reaction with the photometric procedure of Horecker and Brackett. The analyses were repeated after the blood had stood at room temperature for varying intervals up to 4 hours.

The mean methemoglobin by the photometric procedure was only 0.4 per cent of the total hemoglobin. In about half the bloods the methemoglobin percentage observed was so low (0.0 to 0.3) that the presence of methemoglobin was uncertain. The low methemoglobin values confirm Paul and Kemp. The same average value was found whether the blood was analyzed as soon as drawn or 2 or 4 hours later.

The mean inactive hemoglobin by the carbon monoxide method was 1.3 ± 0.35 per cent of the total hemoglobin when the analysis was started 2 minutes after the blood was drawn. The inactive hemoglobin decreased as the blood stood at room temperature, and within 2 hours its average value fell nearly to the level of the photometrically determined methmoglobin.

For precise gasometric hemoglobin determinations the "total hemoglobin" method, based on measurement of CO capacity after reduction of any ferrihemoglobin present to ferrohemoglobin, is more exact than CO or O_2 capacities measured without previous reduction of ferrihemoglobin. - Authors' Sum.

617. Waggoner, J., and Pernell, M.L.: A New method for blood carbon monoxide determination. U.S. Armed Forces Med. J. 6:121-124, 1955.

The major problem during an investigation into aviation hazards conducted at the U.S. Naval Air Station in San Diego, Calif., was that of performing any sizeable number of blood CO determinations, whereby large numbers of blood CO analyses could be readily devised. The new method for determining blood carbon monoxide levels described in this paper is believed to be quicker and more accurate and less expensive than methods in use. Authors state, if this method is generally adopted, it will stimulate an increase in the number of blood CO determinations whenever personnel are exposed to products of combustion or oxidation. Thus a greater degree of public safety may be obtained. - AGC

618. Wilson, R.H., and Jay, B.E.: Respiratory and blood gas analysis with vapor phase chromatography. Clinical Res. 8:92, 1960.

Measuring the parameters of pulmonary functions by employing a complex mixture of inert and chemically active gases presents difficult analytical problems. The gas chromatograph was used for the analysis of a mixture of carbon monoxide, helium, carbon dioxide, oxygen, nitrogen and nitrous oxide. The gas chromatograph and the method of Van Slyke and Sendroy were compared in the analysis of the above mixture. When the two methods of analysis were compared, no significant difference between the results of the measurements were noted. For research and a complex gas mixture can be analyzed more rapidly with less expenditure of effort with the gas chromatograph. In analyzing blood gases the gas chromatograph provides a simple, rapid, time-saving procedure. - AGC

CONTROL

619. Abatement of Highway Noise and Fumes. Highway Research Board Bull. 110, Washington, D. C., 1955, 47 pp.

This bulletin contains three separate studies. There are two reports on the abatement of highway noise and one report on reduction of motor vehicle fumes in which the toxicity of carbon monoxide is discussed. It is stated in this report that dangerous concentrations of carbon monoxide may be present in motor vehicles on open highways in both light and heavy traffic, in congested city streets, in enclosed places such as garages, bus terminals, and the like. This gas may on occasion, be drawn into office buildings and business places through ventilating systems and open windows.

In California, more than 1,000 vehicles were tested for carbon monoxide after they had been driven over an open highway for five minutes or more. Two percent of the vehicles were found to contain dangerous concentrations that could seriously affect the behavior of drivers. One surprising fact brought out was that vehicles with one or more open windows were generally found to have higher concentrations than vehicles with closed windows. This is contrary to the general belief that open windows are a safeguard against dangerous traffic fumes.

It should be mentioned that exposure to relatively low concentrations of carbon monoxide for long periods, may be as dangerous as exposure to higher concentrations for shorter periods. Temperature and humidity also have a decided influence on the effect of carbon monoxide. Concentrations that would normally be harmless may be dangerous on days of high temperature and high humidity. The American Standards Association considers maximal permissible concentrations as 100 parts per million for periods not exceeding eight hours and 400 parts per million for periods not exceeding one hour, at 25 deg. C and 760 mm Hg. - From text-AGC

620. Burrell, G.A.: The Use of Mice and Birds for Detecting Carbon Monoxide after Mine Fires and Explosions. U.S. Bureau of Mines Tech. Paper #11, 1914, 15 pp.

Bureau of Mines is carefully studying methods to be employed with greatest efficiency for exploring mines containing smoke or suffocating or poisonous gases. The use of mice and birds is, in the author's opinion, superior to chemical tests for CO in that the tests are quickly made without requiring technical experience, and that such tests are sufficiently accurate. Because the rate at which chemical changes occur in mice and birds is by far greater than it is in man, symptoms of poisoning are much earlier manifested. A mouse weighing one-half ounce consumes about 15 times as much oxygen as one-half ounce of the human body would consume during the same time. One investigator observed that with 0.1% CO in the air about two hours elapsed before giddiness, etc. began to appear in a man at rest, and according to an analysis of the blood, exposure for another half hour would have sufficed to produce practical disablement. A mouse became giddy within 10 minutes. Experiments similar to those performed with mice were performed with birds, for the reason that mice may be slow responding to the presence, in the mine air, of such small percentages of CO, which would cause distress to a man at work. The relative susceptibilities of mice and canaries to CO is shown in a table.

The properties of CO and its physiological effect on man are also described. - AGC

621. Campbell, J.M.: Improved combustion held aid to air pollution abatement. SAE J. 62:54-58 (Dec.) 1964.

This paper relates the efforts of the auto industry to minimize pollution from the internal combustion engine. Current products represent the best of today's knowledge, but substantial further progress will be made as new information becomes available. Carbon monoxide, smoke and odor represent inefficient combustion and as such indicate a waste of fuel as well as the nuisance that is created by them. Exhaust treating devices have been invented, but at the present time none is available which meets all specifications in order to be commercially practicable. Automobile Manufacturers Association is supplementing joint research programs relating to this general problem. - AGC.

622. Campbell, O.F., and Pennels, N.E.: CO boiler and fluidized-bed steam superheater on Sinclair Refining Company's new fluid unit at the Houston Refinery. Trans. ASME 77:927-938 (Aug.) 1955.

The combination CO boiler and respray steam superheater allows for maximum flexibility of operation of a fluid unit to produce more and better products and provides maximum conservation of fuel. In addition it prevents carbon monoxide, hydrocarbons and maladorous gases from escaping to the atmosphere, and it conditions the flue gases for subsequent removal of particulate matter.

Over 300,000 pound/hour of 700 psig. saturated steam are produced by the oil industry's first direct-fired unit to recover both the sensible heat and the heat of combustion from the high-temperature regenerator-exit flue gas. The heat of combustion of the regenerator-exit flue gas is derived from its CO content. Saturated steam produced in the boiler is superheated to 750° F. in industry's first fluidized-bed respray steam superheater. - APCA 447

623. Chovin, P.: Studies of Atmospheric Pollution in the Department of the Seine, in 1963. Municipal Laboratory Police Headquarters, Paris, France, 1964.

1963 test results for continuing studies in Paris, France, titled "Carbon Monoxide," "Policemen 1963," "Seine Loop," and "Smokeless Zones," are reported. Previous years' results are confirmed. Surface and underground tunnel measurements of CO in air are compared. The CO pollution level in the air went from "considerable" in 1962 to "serious" in 1963, but in the first 9 months of 1964, the situation reversed to that of 1962. The increase in 1963 is ascribed to the number of new roads and concurrent traffic increase. CO levels in blood were examined in a CO-exposed population consisting of industrial employees, auto drivers involved in accidents, and individuals suffering from CO exposure. Tests for "average real risk" of carbon monoxide absorption by individuals indicated that the auto drivers as a group had a much higher level of carbon monoxide in the blood than that of the rest of the population studied, including workers exposed professionally. - CBK (from French)

624. Clarkson, D., and Middleton, J.T.: The California control program for motor vehicle created air pollution. J.APCA 12:22-28 (Jan.) 1962.

California was assigned a new role in the battle against air pollution in 1960 when legislation was enacted which established the Motor Vehicle Pollution Control Board and a program to control air pollution created by the motor vehicle. The legislation extended the State's role in air pollution control beyond its traditional one of research and assistance to local governmental agencies to one of direct control. The State thus is now responsible for controlling moving sources of pollution while local agencies retain their long-standing responsibility for control of stationary industrial and domestic pollutors. Whereas local agencies have instituted programs designed to control the stationary sources which vary in number, kind, and importance as pollutors in various areas of California, a technically sound and administratively feasible program of control of vehicular emissions can be achieved only by the state level of government. Uniformity in the requirements for control throughout the State is necessary because of the mobility of motor vehicles without regard to local political boundaries and because they are an air pollution factor common to all densely populated areas of the State. A State program insures equitability in the application of control requirements and ease of administration.

This paper discusses the program instituted by the Motor Vehicle Pollution Control Board, which represents a first attempt to control air pollution created by motor vehicles, an essential step to achieve satisfactory air quality throughout California. -Authors' introduction -AGC

625. Crankcase emission control devices for typical gasoline engines. Information Report No. 1 (TA-10 Vehicular Exhaust Committee. Chairman: Jensen, D.A.) J.APCA 13:173-174 (April) 1963

The purpose of this report is to present information to the APCA membership on various systems for the control of hydrocarbon emissions from motor vehicle crankcases. Three classes of device are considered. The report also presents information regarding the qualitative and quantitative characteristics of crankcase contaminant emissions from typical gasoline engines. Because crankcase emissions from diesel engines have been found to be very low, these engines do not require crankcase control devices and are not considered in this report. -Author's Introduction

626. Cribb, G.S., and Marsh, J.D.F.: Removal of carbon monoxide from fuel gases. Gas World (London) 150:633 (Nov. 21) 1959.

Carbon monoxide can be removed from town gas by catalytic reaction with hydrogen to give hydrocarbons, by absorption in cuprous salt solutions or by reaction with steam on a catalyst to give carbon dioxide and hydrogen. The last method, known as the water gas shift reaction is the most promising. Processes widely used for gases available at pressures of 20 atm. become uneconomic if the gas has to be compressed solely for the purpose of removing carbon dioxide. Of the methods available for treatment of the gas at atmospheric pressure, chemical absorption by ammonia or activated potash solutions, and absorption by molecular sieves appear to be most promising. - APCA 2939

627. Cumming, A.P.C., and Horn, J.A.: Studies in acetylene flames. IV. Dangers associated with carbon monoxide produced from acetylene lamps in coal mines. J. Appl. Chem. (London) 1:198-202 (May) 1951.

The present paper is an endeavour to interpret the experimental results (previously obtained by the present authors) from the point of view of safety in mines in which open acetylene lamps are used as the source of illumination. The danger caused by the formation of CO from acetylene lamps in isolated workings becomes distinctly serious when the oxygen content of the atmosphere falls to 17% or below. At this concentration of 17% oxygen, and operating with two acetylene lamps (2-inch flames) in an isolated working of 1000-cubic foot capacity, the concentration of CO in the working could reach the value of 0.79% after a period of 8 hours. It is estimated that under these conditions the time of exposure required to cause death would be under 2 hours.

Tables are provided which enable the concentration of CO in an atmosphere to be estimated under any particular conditions. - Authors' Abst.

628. Edwards, H.D.: The removal of carbon monoxide from town gases. Coke & Gas (London) 22:331-336 (Aug.) 1960.

Methods of reducing the carbon monoxide content of coal gas blended with gases high in carbon monoxide have been investigated. The most promising method appears to be the water gas shift reaction; the carbon monoxide is converted by reaction with steam to carbon dioxide with the simultaneous production of hydrogen. - APCA 3645

629. Feasibility of Control Methods for Automobile Exhaust. Report No. 10, Air Pollution Foundation, Los Angeles, Calif., 1955, 62 pages.

This report is based on a study by the Southwest Research Institute, San Antonio, Texas. The general subjects considered are: alternate fuels (liquified petroleum gas, alcohol and alcohol-gasoline blends, and nonleaded gasoline); devices which treat exhaust gases; and devices which modify engine-operating conditions. Most of these proposed methods were found impracticable or too expensive. The greatest promise in lessening auto fumes probably lies in the use of catalytic converters, or afterburners, or a combination of a fuel shut-off device and improved car maintenance. APCA 742

630. Fenimore, C.P., and Jones, G.W.: The water-catalyzed oxidation of carbon monoxide by oxygen at high temperature. J. Phys. Chem. 61: 651-654, 1957.

By sampling burnt gases from lean flat hydrocarbon flames at one atmosphere pressure, the oxidation rate in the presence of ample water at 1700-2000° K. is determined to be $-1/(O_2)(d\ln(CO)/dt) = 1.2 \times 10^9\ e^{-24,000/RT}(\text{moles/l.})^{-1}\ \text{sec.}^{-1}$. In the burnt gas from carbon monoxide flames, containing very little water, $-d\ln(CO)/dt$ is independent of oxygen and roughly proportional to water. The slower rate of comparatively dry carbon monoxide flames is raised toward the value appropriate to hydrocarbon flames by adding hydrogen to the carbon monoxide. A partial mechanism is suggested which is consistent with these results. - Authors' Abst.

631. Forbes, H.S.: A survey of carbon monoxide poisoning in American steel works, metal mines, and coal mines. Indust. Hyg. 3:11-15 (May) 1921.

Carbon monoxide as met with in metal and coal mines and about blast furnaces in this country rarely causes late aftereffects following acute severe gassing. When such effects do appear, there is evidence, almost always, of a pre-existing pathological condition.

Frequent exposure to carbon monoxide causes headache and malaise, but no evidence has been found of a cumulative harmful effect.

As was to be expected, owing to the compensating increase of hemoglobin and red cells from prolonged oxygen want, it is possible to acquire some tolerance to carbon monoxide.

A recent advance in treatment has been made by adding carbon dioxide to the oxygen inhalations administered. Recovery is three times as rapid as when oxygen alone is used.

An efficient portable carbon monoxide respirator has been perfected by the U. S. government. - Author's Sum.

632. Forbes, J.J., and Grove, G.W.: Mine Gases and Methods for Detecting Them. USBMC 33, 1954, 82 pp.

In this publication, detailed information is given on the nature and occurrence of mine gases and mixtures of gases. Detection of gases is so important that the various methods are treated at length. Particular attention is given to flame safety lamps; methane-indicating instruments; various types of carbon-monoxide detectors; methods for detecting atmospheres deficient in oxygen or containing accumulations of black-damp; and methods for detecting hydrogen sulfide, oxides of nitrogen, and sulfur dioxide. - Authors' Introduction

633. **Hayashi, S.:** Present situation of the control of public hazards in Japan. Kuki Seijo (Tokyo) 1:8-12 (March) 1964.

Accompanying the rapid economic growth of Japan since 1959, there has been the establishment of 19 public agencies for the control of hazardous environmental conditions. Previous to this time there were only 2 such agencies. In this review are discussed various legislative measures, some statistics on the number of hazardous happenings during the years 1962 and 1963, and some of the kinds of public hazards. Among the latter are enumerated noise, water pollution, mining dust and gases, agricultural chemicals, dust pollution, and vibration. The amounts of deposited soot, measured mainly in 1961, at various places in Japan are tabulated. The maximum was 137 tons/km.^{2}/month at Wakamatsu. At Kamaishi it was 116 tons/km.^{2}/month and at Yahata it was 113 tons/km.^{2}/month. The maximum amount of SO_2, expressed as SO_3, was 6.44 mg./100 cm.^{2}/day at Kawasaki. The amount of CO and NO_2 in car exhaust gases, in the air of some large cities reached values of 10-20 ppm. and 0.02-0.05 ppm., respectively. The general trend of air pollution is that the amount of deposited soot is decreasing while the amount of SO_2 is increasing; the amount of suspended dust is remaining constant. - APCA 6417

634. Heinen, C.M.: Using the engine for exhaust control. Presented at the Los Angeles Section of the Society of Automotive engineers Nov. 19, 1962.

The 1956 CRC Field Survey and the recent survey by the MVPCB both show wide variations in the carbon monoxide and hydrocarbon content of the exhaust of vehicles in the field.

There is strong evidence to show that the primary reason for these variations is engine condition.

For Chrysler cars now in the field, readjustment to and maintenance at factory specifications would result in values of about 500 ppm HC and 2.0 - 2.5% CO. This is an almost essential step for every type of additional control, whether it be by devices or engine modification.

Various engine modifications dealing primarily with the carburetor and distributor are possible on Chrysler vehicles which reduce the emissions to 275 ppm HC and 1.5% CO or below, and which have no substantial effect on performance.

With the possible exception of the idle adjustments (mixture and rpm) the normal factory recommended intervals should be adequate for maintaining vehicles at these levels. No special tools are required.

Maintenance of the type specified by the manufacturers for good vehicle operation should be strongly urged as an air pollution measure. No new garage equipment is required.

As soon as the present series of tests on engine modifications are completed, a production test on the modified engines discussed above will be justified unless some unexpected difficulty arises during the rest of the tests.

A production test of this type represents the final step prior to production and is conducted with the help of a substantial nummber of motorists. The object, of course, is to confirm that the experimental findings are verified by customer experience. - Author's Abst.

635. Hofer, L.J.E., Gussey, P., and Anderson, R.B.: Specificity of catalysts for the oxidation of carbon monoxide-ethylene mixtures. J. Catalysis 3:451-460 (Oct.) 1964.

The specificity of five different catalysts for the oxidation of ethylene and carbon monoxide was determined in a microcatalytic reactor at temperatures from 50° to 600° C. On all five catalysts carbon monoxide oxidized more readily than ethylene. Complete removal of carbon monoxide occurred on the cobalt oxide at room temperature, on the copper oxide-chromium oxide on alumina catalyst at 100° C, on both copper oxide and iron oxide at 200° C, and on chromium oxide at 450° C. On cobalt oxide, iron oxide, chromium oxide, and the copper oxide-chromium oxide on aluminum oxide the presence of carbon monoxide enhanced the oxidation of ethylene. Conversely the presence of ethylene inhibits the oxidation of carbon monoxide markedly in the case of cobalt oxide and iron oxide. Significant chemisorption at any temperature was not observed for chromium oxide or copper oxide. The other three catalysts showed significant quantities of chemisorption for both ethylene and carbon monoxide. With chromium oxide, ferric oxide, and cobalt oxide, hydrogen was produced in amounts up to 2% of the hydrogen in the initial ethylene. - Authors' Abst.

636. Jensen, D.A., and Seanlin, J.R.: Methods of reducing pollution caused by internal combustion engine (motor vehicles.) Aspects Techniques de la Sécurité Routière. 19:1-24,29 (Sept.) 1964.

Methods for the control of pollution from internal combustion engines in California, are discussed in this paper. Devices have been developed to recirculate crankcase gases back into the engine and burn them. Catalytic mufflers and direct flame afterburners have been developed to oxidize hydrocarbons and carbon monoxide. There is a requirement that all diesel trucks and buses use high-grade fuel and to be well maintained to reduce air pollution respectively the smog problem. Four new exhaust systems have been approved by the California Motor Vehicle Pollution Control Board, which will have to be fitted to all vehicles beginning Jan. 1966. -AGC.

637. Kerr, J.A., and Calvert, J.G.: The formation and decomposition reactions of the acetyl radical and the heat of formation of the acetyl radical. Phys. Chem. 69:1022-1029 (March) 1965.

The 3660-Å. photolyses of azomethane in the presence of either carbon monoxide or acetaldehyde have been investigated, and the formation and decomposition reactions of the acetyl radical have been shown to be dependent on the over-all pressure in the system. The activation energies obtained for the decomposition and formation reactions of the acetyl radical are consistent with recent results of O'Neal and Benson. A combination of the present results and recent independent estimates gives $\Delta H_f°(CH_3CO) = -4 \pm 2$ kcal./mole. Results on the reaction (8) $CH_3 + CH_3CHO \dashrightarrow CH_4 + CH_3CO$ have been obtained from the azomethane-acetaldehyde system and together with three other determinations yield the Arrhenius equation: $k_8 = 10^{11.5}e^{-6.8/RT}$ cc./mole-sec. The approximate rate constant for the reaction (10) $CH_3 + (CH_3)_2N_2 \longrightarrow (CH_3)_2NNCH_3$ was derived from the data: $k_{10} = 10^{11.7}e^{-7.1/RT}$ cc./mole-sec. - Authors' Abst.

638. Linville, W., Holmes, R.G., and Kanter, C.V.: Evaluation of methods for controlling vehicular exhaust. J. APCA 10:21-28 (Feb.) 1960.

The problem of reducing smog forming contaminants from automobile exhaust gases has for several years been the subject of study by air pollution control agencies, the automotive industry, engineering firms, research institutions, and independent inventors. Methods and devices which have been evolved, the principles upon which they are based, and their capabilities for controlling exhaust gas contaminants are described. These include fuel modifications, deceleration fuel shutoff devices, vacuum breakers, exhaust gas purifiers, direct flame afterburners, catalytic mufflers, and others. These studies indicate that complete control of the organic contaminants will require an afterburner, either catalytic or direct flame, but lesser degrees of control may be achieved by some of the other devices or methods which have been proposed. Although no automotive control device has as yet reached the stage of commercial availability, development is progressing at an encouraging rate. - APCA 2934

639. Methods of Reducing Pollution Caused by Internal Combustion Engines (Motor Vehicles). (General Report.) European Conference on Air Pollution, June 24-July 1, 1964. Council of Europe, Strasbourg (France), 1964, 40 pp.

This General Report, published following the European Conference on Air Pollution, is presented by Prof. Brunner, Federal Institute of Technology, Zurich, and Laboratoire fédéral d'essai des Matériaux, Switzerland; and Mr. Lemaigre, Président de l'Union Technique de l'Automobile, du Cycle et du Motorcycle, Paris. The table of contents lists: Introduction; Organization of action to combat pollution from motor vehicles; Studies and research: organization and results; Ways and means of reducing pollution; Anti-pollution legislation. Appendix I (13 pages) is entitled Public and private European bodies concerned with air pollution; Appendix II (26 pages), Bibliography; Appendix III (8 pages), Legislation. - APCA 64-267

640. Thiebault, R.: An interesting experiment, made with the vehicles of the Parisian Préfecture de Police, in order to reduce the rate of carbon monoxide emitted by petrol engines. Centre international de documentation sur l'inspection et la technique des vehicules automobiles. (CIDITIVA Bulletin.) Brussels, No. 23, pp. 2.1-2.11 (Sept.) 1965.

Since 1959, the municipal Laboratories of the Préfecture de Police have been systematically measuring atmospheric pollution in Paris, deducing the general picture from the carbon monoxide (CO) percentage. The many recordings made have led to three main conclusions: (a) Practically no CO during night hours, when motor traffic is sparse. (b) Definite correlation between density of traffic flow and CO rate. (c) Increase of each vehicle's contribution to the CO rate as traffic becomes less fluid, causing vehicles to stop frequently with motor idling. This, together with the fact that idling represents 75% of the time spent on a journey in heavy rush hour traffic, led to the idea of adjusting the relevant arrangements of the carburetor in order to reduce exhaust toxicity to a minimum, without hampering the engine. The method for adjusting the idling and slow running arrangements of the carburetor is described and results obtained are shown in a table. This method was successfully applied to all 1300 police vehicles and brought about the additional advantage of a considerable air pollution abatement in the police garages. Author suggests an education campaign for mechanics and maintenance personnel and wide information of the public on this subject and method. - APCA 64-167

640a. Yanov, A.P.: Control of dust and toxic gases after shotfiring. Gornyi Zhurnal 3:70-73, 1961. S.M.R.E. Trans. No. 4669, CFSTI 63-19814.

An experimental model of a unit for the combined removal of dust and toxic gases from the air after shotfiring is described. Good results were obtained in practical trials of the experimental model of the unit. With concentration of more than 200 mg/m^3 dust, 0.2% carbon monoxide, 0.01% nitric oxides, and 0.8% carbon dioxide, 98 - 99% dust and carbon monoxide were removed from the air, as were 90 - 97% nitric oxides and carbon dioxide. Dustiness of the air after this cleaning process was 1.2 - 1.6 mg/m^3, and the carbon monoxide concentration was 0.0010 - 0.0012%.

The new method of removing dust and gases from the air will make it possible to carry out shotfiring operations during any period of the shift. The heat from the electric heater and from the oxidation of carbon monoxide on hopcalite can be used for the ventilation of the heading, thus eliminating the need for pipelines. - From text-AGC

CRITERIA AND STANDARDS

641. Aviation Toxicology. An Introduction to the Subject and a Handbook of Data. The Blakiston Co., New York, Toronto, 1953, pp. 120.

This handbook on aviation toxicology provides toxicity data on chemicals of special interest in aviation.

CO is the only toxic gas for which allowable concentration limits have been generally prescribed in aviation. The allowable limit of concentration for CO set by military and civilian agencies of different countries vary somewhat. The average limit is one part in 20,000 parts of air (14 b) for civil airplanes in the U.S. In moderate altitudes carbon monoxide does not have any ill effects. Author points out, however, that careful laboratory tests have shown that vision is somewhat impaired at, or even below, this concentration. The concentration of carboxyhemoglobin in the blood stream at high altitude, and the general properties and occurrence of CO are discussed in this book. There are diagrams showing time-concentration curves of CO toxicity. - AGC

642. Bryan, R.J., and Taylor, J.R.: A Review of Air Quality Data Obtained in Ambient Air Animal Exposure Project. Presented at the 58th APCA Annual Meeting, June 20-24, 1965, Toronto, Canada.

Since late 1961 a relatively large-scale study has been conducted in Los Angeles to determine possible biological effects upon animals to the exposure to air pollutants, particularly as related to automotive emissions. The protocol for this study called for the exposure of animals at four separate locations, differing as to the proximity to sources of air pollution from major automobile source areas. At each location, two colonies of animals were exposed--one to unaltered ambient air and one to purified air. The air quality data obtained and reported upon shows distinct pollution patterns with regular seasonal and temporal patterns. A substantial block of data has been obtained on the performance of the air purification system specified as related to contaminants studied, which include ozone, nitrogen oxides, carbon monoxide, sulfur dioxide, hydrocarbons, and particulate matter. Some limited study on the reproducibility of various instrumental methods is also reported. An evaluation of the data as relates to this study and its possible usefulness in the planning of future studies is presented. - Authors' Abst.

643. California Standards for Ambient Air Quality and Motor Vehicle Exhaust. Tech. Rept., State Dept. Public Health, Berkeley, Calif., 1960, 136 pp.

Contents: I. The standards and their significance. II. Technical bases for standards for the quality of ambient air. III. The technical bases for motor vehicle exhaust standards. In establishing the standards, an attempt was made to determine what effects the various pollutants were known to have at various levels of concentration on human health and comfort, on animals and plants, and on visibility. The resulting air quality standards together with data concerning motor vehicle emissions and their reactions then became the bases for motor vehicle exhaust standards. The air standards do not establish a fine line below which is good air above which is bad air. They indicate the approx. point at which air under some circumstances may produce undesirable effects. -APCA 3679

644. California Standards for Ambient Air Quality and Motor Vehicle Exhaust. Suppl. I. Crankcase Emission Standard. Maga, J.A., Hass, G.C., and Wong-Woo, H.: State Dept. Public Health, Berkeley, Calif., 1961, 13 pp.

Contents: Introduction. Standard for crankcase emissions. Definition of terms of motor vehicle emission standards crankcase emissions. Crankcase emissions (data, calculations, and revised inventory). Approach to crankcase emission standard (numerical standard, modes of operation, expression of numerical standard). This is supplement 1 to the technical report of 1960. Others will be published as new standards are added. - APCA 4176

645. Carbon Monoxide (Revised 1965). Amer. Indust. Hyg. Ass. 26:431-434 (July-Aug.) 1965.

A revised section on carbon monoxide is continued in the Hygienic Guide Series. Hygienic Standards, toxic properties, industrial hygiene practice, and medical problems are discussed. - AGC

646. Carbon monoxide on the highway. Scientific American 212:52-57 (May) 1965.

Reported in this review is a study by A.J. Haagen-Smit and T.W. Latham who investigated concentrations of CO encountered during eight trips along the commuter route between Pasadena and Los Angeles during peak traffic hours, CO levels near the drives were recorded. The concentration of CO fumes are found to be such as to present a possible danger to the health and driving abilities of the commuter. Normally Los Angeles air contains 10 to 12 parts of carbon monoxide per million parts of air. According to the California State Department of Health, 30 ppm is an "adverse" level and 30 ppm for eight hours or 120 ppm for one hour is a "serious level of pollution." The level measured by the two investigators was 37 ppm; in slow and heavy traffic the average was 54 ppm, with peaks as high as 120 ppm. The level dropped rapidly on less traveled streets but rose again at stop signals. According to Haagen-Smit, two hours in bad traffic would bring the CO concentration in a commuter's hemoglobin to the "serious" level. Studies of the effect of CO on a person's alertness and driving skill are recommended. Automobile exhaust-control devices, mandatory in California beginning with 1966 models, are expected to significantly lower the incidence of smog in general as well as the CO level in particular. - AGC

647. Control of air pollution from motor vehicles and new motor vehicle engines. Proposed Rules. Federal Register Part II, 30:17192-17199 (Dec. 31) 1965.

The maximum allowable rates for discharge of two major automotive air pollutants are similar to standards adopted by California for 1966, and provide: 1. Vehicles with engine displacement of 140 cu. in. or less: (a) hydrocarbons - 375 ppm as hexane (0.165 mole percent carbon atoms) and (b) carbon monoxide - 2.0% by volume. 2. Vehicles with engine displacement in excess of 140 cu. in.: (a) hydrocarbons - 275 ppm as hexane (0.165 mole percent carbon atoms) and (b) carbon monoxide - 1.5% by volume.

The average car without an exhaust control system emits approximately 800 ppm of hydrocarbons and 3.5% carbon monoxide from its exhaust.

In addition to limiting exhaust emissions, the standards are designed to eliminate complete hydrocarbon emissions from the crankcase. - AGC

648. Control of air pollution from motor vehicles and new motor vehicle engines. Federal Register Part II, 31:5170-5178 (March 30) 1966.

Federal standards for the control of air pollution from new motor vehicles were published today in the Federal Register by Secretary of Health, Education, and Welfare John W. Gardner. The standards will apply to 1968 model gasoline-powered passenger cars and light trucks, whether American-made or imported.

The standards, issued under provisions of the 1965 Clean Air Act Amendments, will limit emissions of two major pollutants produced by motor vehicles--hydrocarbons and carbon monoxide. Hydrocarbons are a prime ingredient in the formation of photochemical smog. Carbon monoxide is a lethal gas.

Under the standards proposed on December 31, tailpipe emissions from motor vehicles with engines of 50 to 140 cubic inches cylinder displacement would have been limited to an average of 375 parts per million of hydrocarbons and 2.0 percent carbon monoxide over a vehicle life of 100,000 miles. Engines of more than 140 cubic inches, which produce a greater volume of exhaust gas, would have been limited to an average of 275 parts per million of hydrocarbons and 1.5 percent carbon monoxide.

The final standards call for no change in the limitations on engines in the over-140 cubic inches size range, but significant modifications have been made in the requirements applicable to smaller engines. These have now been placed in two separate categories. For those of 50 to 100 cubic inches cylinder displacement, which include the engines used in most small imported cars, the limitations are now an average of 410 parts per million of hydrocarbons and 2.3 percent carbon monoxide. For engines of 100 to 140 cubic inches, the limitations are an average of 350 parts per million of hydrocarbons and 2.0 percent carbon monoxide.

649. Danger Thresholds. (General Report) European Conference on Air Pollution, June 24-July 1, 1964. Council of Europe, Strasbourg, (France), 1964, 53 pp.

The General Report, published following the European Conference on Air Pollution, is presented by Professor Truhaut, Professor de Toxicologie et d'Hygiène Industrielle à la Faculté de Pharmacie de l'Université de Paris. The table of contents lists the following subject headings: Nature of the risks (risks of immediate toxicity, risks of relatively long-term toxicity, risks of inducing malignant proliferation); Notes of the methodology of assessing risks (laboratory experiments on animals, observations on subjects exposed to pollution); Concept of maximum allowable concentrations applied to chemical air pollutants (significant divergencies, points of agreement -- gas and vapors, and dusts, fumes, and mists); Practical conclusions possible in the light of present toxicological knowledge and economic and social factors; Scope for research and concerted preventive action at European level (biology, analysis, conclusions, bibliography). The Appendix (p. 44-53) consists of Resolutions of the 2 nd International Symposium on Maximum Allowable Concentrations of Toxic Substances in Industry, Paris, April 1-6, 1963. - APCA 64-249

650. Datsenko, I.I.: Disturbances of carbon metabolism in experimental carbon monoxide intoxication. Gigiena i Sanitaria 30:30-34 (May) 1965.

The article contains the results of quantitative analyses of sugar in the blood of animals in a glucose test after introduction of adrenalin and insulin under conditions of a prolonged action of various concentrations of CO. In chronic poisoning concentrations of this gas within the limits of 0.012-0.018 mg/l in the inhaled air produced changes in the glycemic curves. These data may serve as an early diagnostic sign of intoxication, besides. They substantiate the necessity of decreasing the maximum permissible concentration of CO in the air. - Author's Abst.

651. Friberg, L., and Rylander, R.: Scientific basis for some medical air quality guides. J. APCA 15:531-534 (Nov.) 1965.

An attempt to develop medical air quality guides are recently made in Sweden. Even if air pollution is present in only fairly small amounts, problems frequently arise especially concerning nuisance reactions. Present regulations do not provide a basis for a standardized treatment of air pollution problems. The national air pollution situation was discussed and a survey of the literature was performed to collect data concerning current air pollutants. For sulfur dioxide a 30 day value of eight pphm and a two hour value of 25 pphm was recommended. It was further recommended to keep the carbon monoxide concentration as low as possible with an eight hour value of 30 ppm as an absolute maximum. For carcinogenic and mutagenic substances it was also recommended to keep the values as low as possible. Although available data did not support complete medical guides in all cases it was decided rather to have the above approximations than to leave the air pollution situation uncontrolled. - Authors' Abst.

651a Friberg, L., and Rylander, R.: Swedish medical air quality guides. Nord. Hyg. Tidskr. 46:1-32, 1965.

This report is the result of conferences held in Saltsjoebaden, May 27-29, 1964, on the initiative of the State Air Control Board, and at the State Institute for Health on June 11, 1964. The participants, experts from several scientific fields, presented various facets of the problem. Those contributions and the subsequent discussions provide the basis for this report. It is also stated in this report that valuable discussions have been carried on, in course of the work, with Dr. John Goldsmith, of the California State Department of Public Health. The following paragraph is taken from "Summary of Recommendation" of this report:

"At present, a basis is lacking for presentation of pr cise medical recommendations. There are reasons, however, for keeping the carbon monoxide content as low as possible, and under no conditions should it be permitted to exceed 30 ppm (eight-hour value) and 120 ppm (one-hour value). It might be possible by means of relatively limited studies to obtain results on which detailed medical recommendations might be based as was done in the case of sulphur dioxide." - Translated from Swedish.

652. Gilinskiy, V.A., Chapek, A.V., Kozlova, A.G., Kulikova, N.M., and Loshak, A.Ya.: The effect of low concentrations of carbon monoxide on man in pressurized cabins of passenger planes. In: Parin, V.V. (editor): Aviation and Space Medicine. Translation, NASA, Washington, D. C., Dec. 1964. NASA TT F-228, pp. 113-115.

The results of the investigations reported in this paper showed that 3 hours' exposure to carbon monoxide (starting with 0.01 mg/liter or more), both under experimental conditions (ground and pressure-chamber at 2400 m) and during actual flight had adverse effects on the functioning of several organs and systems, namely: higher nervous activity; functions of the visual and vestibular analyzers; metabolic processes; cardiovascular system; muscular strength; tissue respiration and leukopoiesis.

On the basis of the physiological-sanitary data obtained and the results of laboratory tests, it is suggested that the maximum permissible concentration of carbon monoxide in pressurized passenger airplane cabins be 0.01 mg/liter. - From Text

653. Gofmekler, V.A.: The problem of sanitary protection of atmospheric air within the framework of the Council of Mutual Economic Aid. Gigiena i Sanitaria 29:104-106 (May) 1964. Published and Transl. for USDHEW, PHS and NSF, Washington, D. C., by the Israel Program for Scientific Translation, 1965. TT 65-50023/5.

This paper discusses the program planning meeting of the Council of Mutual Economic Aid. Among studies proposed for 1964-1965, is the investigation of the maximal allowable concentrations for 20 combinations of substances in the atmospheric air, which includes carbon monoxide. The combination of SO_2 and CO will be investigated by scientists in Bulgaria. Development of new methods of investigation of atmospheric contamination are contemplated. Along with the development of chemical methods of investigation, greater attention will be paid to physico-chemical methods. The possibility of determination of CO by spectrophotometric methods is being studied in Czechoslovakia. Development of new automatic instruments for the registration of atmospheric contaminants is planned in the German Democratic Republic and in Poland. New methods of sample collection are developed in the U.S.S.R. - AGC

654. Goldsmith, J.R.: Some implications of ambient air quality standards. Arch. Environ. Health 4:151-167 (Feb.) 1962.

The impetus to set air pollution standards for California arose because of the recognition that the improvement - or even maintenance - in the quality of the air in California depended upon control methods for motor vehicle emissions. The law, which in addition to calling for public hearings and for revision of standards from time to time, states that "standards shall be so developed as to reflect the relationship between the intensity and composition of air pollution and the health, illness, including irritation to the senses, and death of human beings, as well as damage to vegetation and interference with visibility." Author discusses standards in other fields and compares industrial threshold limits, with maximal air pollution values, and the alert stages for toxic air pollutants in the Los Angeles County Air Pollution Control District. The community air pollution standards in the U.S.S.R. are also reviewed. Available facts and determination of whether or not standards could be set for, i.e., the group of photochemical oxidants, oxides of sulfur, and carbon monoxide are also considered.

Because of the many sources for carbon monoxide exposure it was decided that only 5% of hemoglobin inactivation by community air pollution would become the basis for standards. Available data on reaction between hemoglobin and carbon monoxide were used to derive the standards - 30 ppm for 8 hours or 120 ppm for one hour. Because the basis of this effect is an interference with physiological function, the standard by definition is at the "serious" level. The 30 ppm standard averaged over 8 hours has often been exceeded in Los Angeles. In the Appendix the policy of the California Standards for ambient air quality are discussed in detail. - AGC.

655. Goldsmith, J.R.: The body burden and air quality standards. Arch. Environ. Health 8:39-43 (Jan.) 1964.

Available work indicates the value of the concept of the body burden in setting air quality standards. So far, the concept has been used in the air quality standards for carbon monoxide. Its use for lead exposures is anticipated and it should be of value for other substances. In addition, the body burden is valuable because of its relevance to exposures not only to elementary substances such as lead and arsenic, but also to complex substances such as chlorinated hydrocarbons. Much additional research is needed in this area. - Author's Sum.

656. Gruber, C.W.: APM-3 Recommended standard methods for continuing air monitoring for gaseous contaminants. TR-2, Air Pollution Measurements Committee. J. APCA 15:313 (July) 1965.

The purpose of Manual APM-3 is to provide a guide which will help increase the uniformity between various surveys, and thereby increase the useability of the data by others. Manual APM-3 will include procedures for the following gases: APM-3.2--Sulfur Dioxide, APM-3.3--Hydrogen Sulfide; APM-3.4--Oxidants and Ozone; APM-3.5--Oxides of Nitrogen; APM-3.6--Carbon Monoxide; APM-3.7--Fluorides; APM-3.8--Hydrocarbons; APM-3.9--Aldehydes.

It is hoped by utilizing Standard Methods for Continuous Monitoring of the Atmosphere air quality data will become more meaningful as monitoring is being carried on by a multitude of governmental agencies research organizations and industry. It is hoped that by standardizing monitoring methods, the path to air quality standard setting will be made smoother. It is also hoped that by utilizing standard monitoring methods our knowledge of what's in the air will be broadened and made more useful to the researchers who are searching out the affects of air pollution upon man and materials. - Author's Sum. Modified.

657. Hass, G.C.: The automobile as a source of air pollution. Trans. Soc. Agr. Engrs. 4:142-143, 1961.

Although much intensive study has been done on the smog situation in Los Angeles the phenomenon is still defined in terms of gross effects. Among the effects are those of eye irritation, aerosol formation, ozone formation, and damage to vegetation. A less well-known fact about automotive air pollution is that the concentrations of carbon monoxide in the atmospheres of poorly ventilated cities are approaching levels at which public health agencies are beginning to be concerned about the physiological effects. For all practical purposes, automotive vehicles are the only significant source of atmospheric carbon monoxide. Although the principal point of emission from a motor vehicle is the tail-pipe, there is also some emission from the crankcase vent, and from the carburetor and fuel tank. Since any scheme to artificially ventilate the air involves moving millions of tons by weight of air, other control methods have to be sought. Last year Los Angeles County adopted a rule requiring the gradual reduction of olefins in gasoline but the benefits are both controversial and costly to the car owner. Deceleration cut-off devices are available and, after further study, were found to be more effective than was thought earlier. Any radical change in engine design appears to be some years off. Major attention is now focused on the development of afterburners for the exhaust system, the 2 types being the catalytic scheme and the direct-flame afterburner. Many companies have such devices under development but the price, and cost of upkeep, are still indefinite. However, a device to control crankcase vent losses is available and inexpensive, and a method of reducing the emissions of oxides of nitrogen has recently been announced. On Dec. 4, 1959, the State Dept. Public Health of Calif. adopted standards of air quality and standards for motor-vehicle exhaust emissions. The 1960 legislature passed a new smog bill which provided for the establishment of a 13-man State Motor Vehicle Poll. Control Board. The bill states that after 1 year from the date on which the Board has certified 2 or more motor-vehicle pollution-control devices, all new cars sold in Calif. shall be equipped with such devices. The application of devices to used motor vehicles is a local option and a longer period of compliance is provided. - APCA 5086

658. Lambertsen, C.J., and Bascom, W.: The Permissible Level of Carbon Monoxide in Inspired Air Univ. Calif. Scripps Inst. Oceanography, Dec. 29, 1953. DDC AD 28055.

The possibility that compressed air breathed by underwater swimmers may contain small amounts of carbon monoxide which could conceivably be injurious, led to a series of letters in which Dr. C.J. Lambertsen, M.D., of the University of Pennsylvania Medical School answered and discussed a series of questions on the subject suggested by Bascom. The Henderson results at one atmosphere are compared with those given in U.S. Bureau of Standards Technical Paper 212 and the wording of

Mine Safety Appliance Co. literature has been borrowed for the first paragraph. Dr. Lambertsen points out that this extrapolation beyond direct measurement is "probably the only information we will have to go on for the next few years." Dr. Lambertsen also states, "I do not want to be held to the absolute values in the tables (graphs) but suspect the relative changes will occur as predicted." - Authors' Abst.

659. McCabe, L.C.: Atmospheric pollution. Indust. Eng. Chem. 47:101A-102A (June) 1955.

The Los Angeles County Air Pollution Control Board recently asked a medical and scientific group to set maximum limits at which pollution levels might be dangerous to public health. Limits were established for oxides of nitrogen, ozone, sulfur dioxide, and carbon monoxide, based on judgment and experience. Instruments are now installed at several stations for continuous measurement of these 4 pollutants and also total oxidant, total hydrocarbons, and wind speed and direction. Standard plant boxes, each containing a variety of smog-sensitive plants, are kept at 12 stations for the detection of crop damaging gases; continuous high-volume filters are used to collect ether-soluble aerosols and radioactive materials. It is estimated that some 14,000 tons of combustible rubbish are disposed of daily by burning, two thirds of it in single chamber incinerators. The incineration of this material releases to the air aerosols, aldehydes, oxides of nitrogen, and organic acids which contribute to reduced visibility, eye irritation, plant damage, and general discomfort. There are more than 1,500,000 single chamber incinerators in use in homes and commercial establishments in the county, and they can not be controlled by practicable engineering refinements. Hence, they will be prohibited in unincorporated areas after June 30, when weekly collection of combustible rubbish is established. Incorporated areas (45 in Los Angeles County) have been asked to expand private or public collection service to permit the prohibition of this type of incinerator by July 1. After June 30, new regulations will apply to open burning. - APCA 390

659a. MacKenzie, V.G.: Conservation of the Air Resources: A National Challenge. USDHEW, PHS, Div. Air Poll., Washington, D.C., Jan. 1965.

The Chief of the Div. of Air Poll. has the following to say in regard to the adoption of the Clean Air Act Amendments of 1965: it became possible for the Federal Government to take still further steps toward dealing with air pollution problems that cannot be satisfactorily resolved at local and State levels. The most important of these steps involves the establishment and enforcement of national standards for the control of air pollution from new motor vehicles.

The proposed Federal standards, which are similar to but somewhat more stringent than those now in effect in the State of California, will require significant reductions in emissions of hydrocarbons and carbon monoxide, two of the principal types of air pollutants discharged through motor vehicle exhaust tailpipes, as well as 100 percent control of hydrocarbon emissions from the crankcase. To comply with the standards, tailpipe emissions from new gasoline-powered vehicles with engines of 140 or more cubic inches cylinder displacement, which includes essentially all American-made cars and light trucks, must not exceed an average of 275 parts per million of hydrocarbons and 1.5 percent by volume of carbon monoxide over a vehicle life of 100,000 miles. For engines of less than 140 cubic inches displacement, primarily those used in small imported cars, the proposed average limitations are 375 parts per million of hydrocarbons and 2.0 percent carbon monoxide. By comparison with the proposed standards, tailpipe emissions from models now in use range upward from about 800 parts per million of hydrocarbons and 3.5 percent carbon monoxide. - From Text

660. Maga, J.A., and Hass, G.C.: The development of motor vehicle exhaust emission standards in California. J. APCA 10:393-396 and 414 (Oct.) 1960.

The motor vehicle exhaust standards adopted by the California State Dept. of Public Health included hydrocarbon monoxide. The standards represent a 1st attempt to set vehicular emission standards as a basis for control legislation. Judgments and decisions were of necessity made on the basis of present knowledge of the smog problem. The calculation of allowable vehicle exhaust emissions includes the following elements: (1) Evaluation of the current levels of air quality experienced on days of meteorological conditions unfavorable to the dispersal of pollutants. (2) Determination of the total vehicle exhaust emissions and the average concentration of pollutants in vehicle exhaust. (3) Determination of the total emissions of air pollutants from all sources. (4) Extrapolation of the emissions data to 1970. (5) Description of the quantitative relationships between air pollution effects and atmospheric pollutant concentrations. (6) Calculation of the necessary reduction in pollutant emissions to maintain the desired air quality of days of meteorological conditions unfavorable to pollution dispersal. (7) Application of these reduction factors to the average exhaust contaminant concentrations. The law provided for periodic revision of the standards when new information becomes available. The goal of the vehicle exhaust standards were: Oxidant index--0.15 ppm. for 1 hour (average value as determined by the potassium iodide method). Carbon monoxide--30 ppm. for 8 hours or 120 ppm. for 1 hour. - APCA 3471

661. Maga, J.A., and Goldsmith, J.R.: Standards for air quality in California. J. APCA 10:453-455, 467 (Dec.) 1960.

The interest in air quality standards has been an outgrowth of the air pollution problem in California. Although the most serious problem is found in Los Angeles, air pollution levels sufficient to cause eye irritation, vegetation damage, and reduced visibility have been experienced in the larger metropolitan regions of the State. It is hoped that air quality standards adopted by the California State Dept. of Public Health will be of value in the State's attack on air pollution and promote studies and research needed to refine and extend the standards. Standards can only be guides and not a substitute for knowledge and good judgment. As in the case for other standards, those for air quality are not precise figures below which there is complete safety and above which there is certain illness and death. They can sometimes be exceeded without injury to an individual. The air standards that have been adopted will have to be used intelligently with the appreciation of their limitations as well as their application. - APCA 3470

662. Middleton, J.T., and Middleton, D.C.: Air pollution and California's state control program. Proc. Amer. Petrol. Inst. 3:636-642, 1962.

Our limited resource is unwittingly being destroyed by man's activities. The destruction of air appears to be correlated with the extent and nature of fuel utilization to meet the energy demands of contemporary society. An increasing knowledge of the causes and nature of air pollution has resulted in changing concepts of control. The state of California, which in 1947 authorized the regulation of stationary sources of atmospheric contamination by local government bodies, is now directly engaged in a program to control mobile sources of contamination through the creation in 1960 of the State Motor Vehicle Pollution Control Board. Air-quality standards developed by the state define both the acceptable air quality and the needed reduction in motor vehicular emissions. While the present program will ensure an improved air quality and thereby reduce damage to health and property, long-range conservation of air will be dependent upon a continuing evaluation of society's fuel utilization, means of transportation, and metropolitan area planning and development. -Authors' abst.

663. Pace, N.: Limits of Tolerance for Carbon Monoxide Under Working Conditions and in Emergency Procedures Aboard Ship. Naval Med. Res. Inst., Nat. Naval Med. Center, Bethesda, Md., NM6-1/A11/NMR1-124, June 12, 1945.

This report is made in response to a request from BuShips for information regarding the limits of tolerance of exposure to various concentrations of carbon monoxide. The limits set forth herein pertain only to non-flying personnel, and must not be applied in other situations where lowered atmospheric oxygen tensions may also be encountered.

Recent work at the Naval Medical Research Institute has led to the development of a general equation for the expression of the rate of accumulation of carbon monoxide in the blood in terms of the factors important to the process. The equation described in this paper has been tested under a wide variety of conditions and found to hold well experimentally and in practice. - Author's Abst.

664. Ryazanov, V.A., Alekseeva, M.V., and Senderikhina, D.Ya.: Methods for the collection and study of air samples in the control of a atmosphere cleanliness in inhabited localities. In: Levine, B.S. (translator) and Ryazanov, V.A. (editor): Limits of Allowable Concentrations of Atmospheric Pollutants. U. S. Office of Technical Services, Washington, D. C., Book 1, 1952, pp. 89-100. OTS 59-21173.

Methods of sampling and sampling devices are described. The sensitivity of the methods recommended for the determination of maximal single concentrations, for the determination of average 24 hours' concentrations using the intermittent method of sample collecting, and sensitivity of the methods recommended for use with samples of continuous 24 hours' aspiration are illustrated in three tables. This information presented indicates that the 24 hours' aspiration method is applicable to 8 ingredients only; carbon monoxide and oxides of nitrogen are best determined by the method of intermittent aspiration. Furthermore, an analysis of the data presented in the Table indicates that the aspiration rate for the ingredients listed ranges between 10 - 5000 l/hour; the total volume ranges between 240 - 12 000 liters. Thus, the tests are so arranged as to make them sufficiently sensitive for the determination of average 24 hours' concentrations, since the tests are from 2 - 8 times as sensitive as required for the determination of the limits of allowable concentrations. - Author-AGC

665. Ryazanov, A.V.: New data on maximum allowable concentrations of pollutants in the air in the U.S.S.R. In: Diamond Jubilee Internat. Clean Air Conference, London, Oct. 1959. National Society for Clean Air, London, 1960, pp. 175-176.

The author points out that the actions of poisonous agents on the human body become inoperative below a definite limit of concentration. This being so, it is only necessary to reduce air pollutants to below the limit at which they become harmful. Russian investigators have set out to determine these limits by conducting experiments on animals, by comparing the changes in human beings living in polluted areas with those living in clean areas, and by carefully controlled laboratory experiments with human subjects. The most rewarding of the results from the last type of experiment have been obtained by demonstrating the reaction of the bioelectric impulses in the brain to quantities of pollutants undetectable by the nose. When fixing maximum concentrations the effects on vegetation, materials and atmospheric clarity are taken into account. Also of great

importance are (1) defensive reactions of the body (showing that condition are not at the optimum,) (2) that any stimulant is undesirable if it operates against a person's free-will. (3) the maximum permissible concentration should be set by reference to the most sensitive index. On the basis of these considerations a tentative table of maximum concentrations for 30 pollutants has been produced and is appended to the paper. - Author's Sum.

666. Ryazanov, V.A.: Sensory physiology as basis for air quality standards. The approach used in the Soviet Union. Arch. Environ. Health 5:480-494 (Nov.) 1962.

Two types of quantitative indexes for degree of atmospheric air pollution are used in U.S.S.R., namely: Maximum Allowable Concentrations for Exposures at any one time and average diurnal concentrations.

The first index is used for considering that degree of prevention of atmospheric pollution which might cause reflextive reaction of the receptors of the respiratory organs including the nose upon a single exposure. The second standard is for the purpose of considering prevention of chronic resorptive action of toxic substances on long-term exposure. This report is limited to the study of reflective action, which is the basis for establishing the M.A.C. for a single exposure. - Author's Sum.

667. Ryazanov, V.A.: New data on limits of allowable atmospheric air pollutants. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 9, 1964, pp. 1-8, CFSTI-TT-64-11574, U.S. Dept. of Commerce, Springfield, Va.

This is a review of papers presented at the Meetings of the Committee on Sanitary Air Protection in 1959 and 1960. The air pollution standards under discussion and the conclusion reached are not to be considered as final. The aim and purpose of the Committee is to stimulate research. In the section on carbon monoxide the papers by L.S. Gorsheleva, and T.M. Shul'ga, are discussed. Animals exposed for six hours to air containing 20-30 mg/m^3 of CO disturbed the conditioned reflexes activity. The Committee adopted 1/10 of this concentration, or 2 mg/m^3 as the MAC average for 24 hours, or three times the average of 24-hour concentration as the maximal allowable single concentration of CO.

The paper by Shul'ga discusses the previously adopted limit of concentration of 6 mg/m^3 of CO in accordance with the definition of a maximal single concentration. The electroencephalographic method which is considered to be most sensitive was used. Results show that 20 mg/m^3 CO had no effect on the reflex reaction of brain biocurrents either directly or through the formation of conditioned electrocardial reflexes. Tested on humans, the maximal allowable single concentration for CO as accepted by the Committee, when inhaled for a brief period of time, had no effect on the human organism. The Committee in regard to Shul'ga's recommendations lowered the average 24-hour concentration limit to 1 mg/m^3, retaining the previously adopted 6 mg/m^3 value as the limit of allowable single CO concentration. - AGC

668. The safety limits of hazardous materials. Safety Maintenance, Dec. 1960, pp. 37-39.

The threshold limit values for 1960 which were adopted at the Twenty-Second Annual Meeting of the American Conference of Governmental Industrial Hygienists, Rochester, N. Y., April 1960, are listed.

The recommended values for gases and vapors are based on the best available information from industrial experiences and from experimental studies. These values are reviewed annually. - AGC

669. Shulga, T.M.: New data substantiating maximum permissible concentration of carbon monoxide in the atmospheric air. Gigiena i Sanitaria 26:3-9 (March) 1961. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 9, 1964, pp. 73-80, CFSTI-TT-64-11574, U.S. Dept. of Commerce, Springfield, Va.

The study was devised to test experimentally the maximum permissible concentrations of carbon monoxide gas in the atmospheric air accepted by the USSR, namely, 6 $mg./m.^3$ as the maximum one-time concentration and 2 $mg./m.^3$ as the daily average concentration. The results obtained indicate that carbon monoxide gas at a concentration of 20 $mg./m.^3$ does not produce any reflex action on the electric activity of the brain. A continuous 24-hour poisoning for a period of 75 days, with carbon monoxide at a concentration of 2 $mg./m.^3$, has produced in white rats some insignificant shifts of motor chronaxy, a fall in the porphyrin metabolism rate, and some reversible changes in individual nerve cells of the cerebrum. The maximum one-time concentration of carbon monoxide in the atmospheric air should remain at its accepted level of 6 $mg./m.^3$, but the daily average concentration should be decreased to 1 $mg./m.^3$. The standard sanitary protection zone of 100 m. around brickworks is insufficient and should be increased to 500 m. - APCA 3818

670. Shulga, T.M.: Data to substantiate the maximum permissible daily average concentration of carbon monoxide in the atmospheric air. Gigena i Sanitaria 30:3-6 (April) 1965.

The work was aimed at obtaining experimental data to substantiate the existing standard value of the daily average concentration of carbon monoxide in the atmospheric air at the level of 1.0 mg/m^3. 24-hour poisoning of albino rats with carbon monoxide gas at average concentrations of 2.65 and 1.13 mg/m^3 was carried out for a period of 2-1/2 months. The investigations performed showed that carbon monoxide at an average concentration of 1.13 mg/m^3 produced no changes in the motor chronaxy, the porphyrin metabolism and had no effect on the functioning of the blood forming systems. Consequently, the existing daily average maximum permissible concentration of carbon monoxide in the atmospheric air at a level of 1.0 mg/m^3 is experimentally substantiated. - Author's Abst.

671. Stern, A.C.: Summary of existing air pollution standards. J. APCA 14:5-15 (Jan.) 1964.

This paper summarizes the existing air pollution standards of the United States, Europe and the U.S.S.R.

672. Stern, A.C.: Basis for criteria and standards. J. APCA 15:281-283 (June) 1965.

Much of the data needed for the development of air quality criteria do not exist and must yet be developed, and when criteria are developed, they will not have about them an air of finality. It, therefore, would be unwise to defer the adoption of emission standards needed now, by postponing such action until air quality criteria and standards become more generally available.

673. Stern, A.C.: Emission standards in air pollution. Amer. J. Pub. Health 55:1075-1081 (July) 1965.

A discussion of emission standards to be employed in dealing with air pollution is presented. It is urged that standards be developed for real situations, which relate both single and multiple sources to the community's air quality standards. The one proposed in this paper is limited to gases and fine particles.

674. Truhaut, R.: Danger Thresholds. European Conference on Air Pollution, held June 24-July 1, 1964, Strasbourg, France, Council of Europe.

This paper presented at this International Conference discusses the following items:

Nature of the risks of immediate toxicity, of relatively long-term toxicity and risks of inducing malignant proliferation.

The methodology of assessing risks by laboratory experiments on animals and observations on subjects exposed to pollution, and how to establish danger thresholds.

Practical conclusions possible in the light of present toxicological knowledge and economic and social factors.

Resolution of the 2nd International Symposium on Maximum Allowable Concentrations of Toxic Substances in Industry are contained in the Appendix, as well as difinitions and the initiation of an agreed international list on values.

675. Vol'fson, Z.G.: Limits of allowable concentration of carbon monoxide in atmospheric air. In: Levine. B.S. (translator) and Ryazanov, V.A. (editor): Limits of Allowable Concentrations of Atmospheric Pollutants. U. S. Office of Technical Services, Washington, D. C., Book 1, 1952, pp. 56-64. OTS 59-21173.

The U.S.S.R. literature on studies concerning CO in the atmosphere is reviewed in this paper. Based on clinical and experimental evidence 20-30 mg/m^3 of CO are considered maximum levels at which disturbances in the central nervous system are noticeable. The recommendation for the adoption of standards was made after thorough study of results of investigation and experiments. The population surveyed consisted of children, aged, sick, and generally feeble persons. Following recommendations were made: The maximal allowable limit of average daily CO concentrations in the city atmosphere is not to be above 2 mg/m^3. Maximal single concentration of CO in the atmospheric air must not exceed 6 mg/m^3. - AGC

676. Zimmer, C.E., and Larsen, R.I.: Calculating air quality and its control. J. APCA 15:565-572 (Dec.) 1965.

Air quality is shown as a function of averaging times of five minutes to one year for carbon monoxide, hydrocarbons, nitric oxide, nitrogen dioxide, nitrogen oxides, oxidant, and sulfur dioxide in Chicago, Cincinnati, Los Angeles, New Orleans, Philadelphia, San Francisco, and Washington, D. C. Concentrations are approximately lognormally distributed for all pollutants in all cities for all averaging times. Maximum concentration is inversely proportional to averaging to an exponent. The exponent is a function of the standard geometric deviation. General air quality and control parameters are derived and shown for one example, nitrogen oxides in Washington, D. C. These values are compared to one air quality standard. - Authors' Abst.

INSTRUMENTS AND TECHNIQUES

677. Anderson, T., and Dahlstrom, H.: A clinical method for the determination of carbon monoxide in air. Sc. Tools (Stockholm) 5:9-11 (April) 1958.

An objective method for determining the concentration of carbon monoxide in air in the range 1-100 ppm. using indicator tubes according to Shepherd is described. The sample is passed at a constant flow rate through the indicator tube mounted in the optical path of a Beckman Model-B spectrophotometer and the time required to obtain a certain extinction value is measured. This time is a function of the CO concentration in the sample. The sensitivity of the method is very high and corresponds to an error of the order of 1-6% in the range investigated. In addition, it

has several considerable advantages over earlier methods. Once a calibration curve has been obtained, the method is absolute and requires no standard gas mixtures. It is completely independent of the existing lighting conditions as well as of the investigator's color sense. It is easily adapted to different ranges of carbon monoxide concentrations. Finally, a relatively small quantity of sample gas is required even at very low CO concentrations. - APCA 2118

678. Auckland Air Pollution Research Committee. Sixth Annual Rep. 1965. P.O. Box 2225, Auckland, New Zealand, 42 pp.

Three years of the planned five year survey are summarized in this Sixth Annual Report. The main task of the Committee has been the study of the meteorological and topographical conditions, the survey of air pollution in the metropolitan area of Auckland and air pollution emanating from motor vehicles. New and modern equipment and measuring methods have been employed and in particular with regard to CO, a non-dispersive infra-red CO analyser (sensitized to CO) was made available. The first attempt to measure air pollution from motor vehicles was made in summer 1962/63. No further measurements were undertaken until this device was obtained late in 1964. This instrument was modified by the addition of a 6-point potentiometric recorder, so that the timing mechanism of the recorder operated four solenoids in sequence, allowing samples to be obtained from four different locations at one minute intervals. The remaining two points of the recorder were used for recording wind speed and direction, and provision was made for the sampling lines to each sampling point to be flushed continuously with the air being sampled. This allowed a continuous recording to be made of the CO levels at four different locations at the site under investigation. The maximum CO concentration recorded was 42 ppm during a morning traffic peak and the average two hour value in which this peak was included was 24 ppm. Following sampling method was used: A 5 litre sample of air was obtained by allowing this amount of water to drain slowly from a polythene container over a period of an hour. The air collected above the water was analyzed using a Drager gas detection. - AGC

679. Ayen, R.J., and Ng, Yu-Sim: Catalytic reduction of nitric oxide by carbon monoxide. Internat. J. Air & Water Poll. 10:1-13 (Jan.) 1966.

Rate data for the catalytic reduction of NO and CO were obtained using a flow reactor operated differentially at atmospheric pressure and at temperatures of 160,200,220 and 240° C. Nitric oxide and carbon monoxide partial pressures were varied from 0.005 to 0.05 atm using helium as a diluent to bring the total gas flow to 2000cc/min. A dual site mechanism was postulated for the reaction in which the rate determining step was a surface reaction between adjacently adsorbed CO and NO molecules. From the data, rate and adsorption constants were evaluated for the corresponding rate expression. This expression is of practical use in the design of a catalytic converter to remove oxides of nitrogen from automotive exhaust gases and other exhaust streams. - Authors' Abst.

680. Ayer, H.E., and Saltzman, B.E.: Notes on interferences by oxides of nitrogen with estimations of carbon monoxide in air by the NBS indicating tubes. Amer. Indust. Hyg. Ass. J. 20:337-339 (Aug.) 1959.

Nitrogen dioxide and nitric oxide interference with carbon monoxide estimations by the NBS indicating tube were investigated. Both oxides were found to interfere seriously, the nitrogen dioxide to a great extent. Nitrogen dioxide interference can be eliminated and nitric oxide intereference considerably reduced by using a U-tube with solid potassium permanganate in the upstream leg and Ascarite in the downstream leg. The U-tube is flushed with the contaminated air, using the rubber bulb, and then connected ahead of the indicating tube. The field determination of carbon monoxide is then made in the usual way. No interference may be expected from concentrations of nitrogen oxides up to 15% of that of carbon monoxide. If an NBS tube estimation without the U-tube does not give a color lighter than one made with the tube, then nitrogen dioxide can be presumed to be within its threshold limit of 5 ppm. The degree of interference eliminated by the tentative method reported here was sufficient for immediate needs. - APCA 2732

681. Bangert, F.: Measurement equipment for CO by application of the Dräger-CO-Messers Model E. Dräger-Hefte Heft 236:5176-5179, 1959.

This paper describes the Dräger CO measuring device in use for the last 30 years. The analysis of carbon monoxide content in oxidized gas mixtures up to concentrations of 0.001 Vol.-% is based on the heat tone brought about in the mixture to be investigated. Author describes the difference between the Dräger Model T and E the new model, which is a fully automatic CO measurement and alert instrument for continuous operation. This model equipped with a special recording instrument with compensation amplifier, is able to register the CO-content far below the maximum allowable concentration to about 0.0003 Vol.-%. This instrument can also be equipped with a maximum transmitter which enables it to give optical and acoustical warning signals when a certain CO content is reached, or to activate automatically the operation of ventilators. - AGC

682. Bryan, R.J.: Instrumentation for an ambient air animal exposure project. J. APCA 13:254-265 (June) 1963.

The design of facilities, including ambient air room ventilation and control room air purification systems, has been discussed in connection with a project for the evaluation of biological effects on animals from automobile related air pollution. The selection of air monitoring instruments, including the evaluation of two new instruments, and the air sampling system design for this project has also been treated.

In the design of facilities the most important problem encountered was that of existing limitations on air purification systems. The experimental design concept used in this project called for no alteration of the breathing air provided to control animals except for the removal of air contaminants. It was not possible to provide such a system in which removal of carbon monoxide, lower molecular weight hydrocarbons, and nitric oxide, could be accomplished effectively. Operating experience to date, however, indicates that the air purification system selected does remove ozone, higher molecular weight hydrocarbons, nitrogen dioxide, and filterable black aerosols quite effectively. - Author's Sum.

683. Burrell, G.A.: The Use of Mice and Birds for Detecting Carbon Monoxide after Mine Fires and Explosions. U.S. Bureau of Mines Tech. Paper #11, 1914, 15 pp.

Bureau of Mines is carefully studying methods to be employed with greatest efficiency for exploring mines containing smoke or suffocating or poisonous gases. The use of mice and birds is, in the author's opinion, superior to chemical tests for CO in that the tests are quickly made without requiring technical experience, and that such tests are sufficiently accurate. Because the rate at which chemical changes occur in mice and birds is by far greater than it is in man, symptoms of poisoning are much earlier manifested. A mouse weighing one-half ounce consumes about 15 times as much oxygen as one-half ounce of the human body would consume during the same time. One investigator observed that with 0.1% CO in the air about two hours elapsed before giddiness, etc. began to appear in a man at rest, and according to an analysis of the blood, exposure for another half hour would have sufficed to produce practical disablement. A mouse became giddy within 10 minutes. Experiments similar to those performed with mice were performed with birds, for the reason that mice may be slow responding to the presence, in the mine air, of such small percentages of CO, which would cause distress to a man at work. The relative susceptibilities of mice and canaries to CO is shown in a table.

The properties of CO and its physiological effect on man are also described. - AGC

684. Campbell, O.F., and Pennels, N.E.: CO boiler and fluidized-bed steam superheater on Sinclair Refining Company's new fluid unit at the Houston Refinery. Trans. ASME 77:927-938 (Aug.) 1955.

The combination CO boiler and respray steam superheater allows for maximum flexibility of operation of a fluid unit to produce more and better products and provides maximum conservation of fuel. In addition it prevents carbon monoxide, hydrocarbons and maladorous gases from escaping to the atmosphere, and it conditions the flue gases for subsequent removal of particulate matter.

Over 300,000 pound/hour of 700 psig. saturated steam are produced by the oil industry's first direct-fired unit to recover both the sensible heat and the heat of combustion from the high-temperature regenerator-exit flue gas. The heat of combustion of the regenerator-exit flue gas is derived from its CO content. Saturated steam produced in the boiler is superheated to 750° F. in industry's first fluidized-bed respray steam superheater. - APCA 447

685. Carbon Monoxide Indicator. Progress Reports No. 18 and 19. Kollsman Instrument Corp., Elmhurst, N.Y., May 21, 1954, 3 pp., 4 figures. DDC AD 34066.

This report describes the progress in the development of a carbon monoxide indicator of the thermometric type. The major portion of the work during this period was the continuation of the construction of the final instrument. The various components previously constructed were combined into a compact arrangement, which included the flow-rate-control and pressure-control elements, the humidifier, the alumina hydrocarbon filter, and the reaction-tube holder. - Authors' Abst.

686. Carey, G.C.R., Phair, J.J., Shephard, R.J., and Thomson, M.L.: Portable carbon monoxide uptake apparatus. A.M.A. Arch Indust. Health 16:225-231 (Sept.) 1957.

This paper describes a portable apparatus developed for the 1956 air pollution survey and subsequent modifications that permit the more accurate determination of pulmonary diffusing capacity. The apparatus gives approximate values for both functional residual capacity and carbon monoxide uptake. The limits of accuracy are defined on theoretical grounds, and is adequate to follow variations in the physiological state of a given patient, provided that tidal volume and respiratory rate are carefully controlled during the test. APCA 1547

687. Chemical Watchbirds. Indust. Eng. Chem. 45:17A-18A (March) 1953.

The development of carbon-monoxide and sulfur-dioxide detectors, in the form of silica gel impregnated with color indicating complexes, is discussed. Vanadate-impregnated gels detect sulfur-dioxide concentrations up to 120 ppm by changes from bright yellow to dark green, while potassium periodate detects concentrations up to 675 ppm as the gel changes from white to pink. Although little is known about the reaction itself, quantitative measurements are determined by reference to standard colors. - LC

688. Chinn, H.I.: A Method for the Determination of Carbon Monoxide in Alveolar Air, Together with a Correlation of Values Thus Obtained with Carboxyhemoglobin Concentrations in Blood. Aviation Medicine Randolph AFB, Texas, April 5, 1944, 9 pp. DDC AD 135575.

A simple method has been devised for the determination of carbon in alveolar air. An excellent correlation has been shown between the alveolar carbon monoxide content and the carboxyhemoglobin concentration in blood. This procedure possesses the following advantages: ease of operation, rapidity of analysis, omission of blood samples, use of untrained personnel, avoidance of all solutions, and compactness of apparatus. Its disadvantages lies in the necessity for subject co-operation so that determination cannot be made on unconscious or dead persons. Replacement of oxyhemoglobin by carboxyhemoglobin cannot be demonstrated by oximeter measurement. - Author's Abst.

689. Chipman, J.C., and Massey, M.T.: Proportional sampling system for the collection of an integrated auto exhaust gas sample. J. APCA 10:60-68 (Feb.) 1960.

The proportional sampling system continuously meters and accumulates a constant percentage of the exhaust gas. The electronic and analytical evaluation studies indicate that the system is reliable within the desired over-all accuracy of 90% and responds to the normal engine transient operating conditions throughout the test run. The system eliminates the need of tedious manual integration of individual operating conditions. Over-all evaluation of the exhaust gas emissions from a test run is obtained from 1 sample. Limitations are not imposed on the number of analyses that can be performed or the techniques employed. The accumulated sample can be used as a representative automotive gas source for many research experiments such as exhaust gas composition studies, reaction kinetics, plant fumigation, and eye irritation studies. - APCA 3397

690. Ciuhandu, G; Photometric determination of carbon monoxide in the air. Fresenius Zeitschrift für Analytische Chemie 155:321-327, 1957.

A photometric process of CO determination based on gas absorption in an alkaline silver compound solution of the p-sulfonamide-benzoate is discussed in this paper. The silver compound is being reduced to metallic silver which remains in colloidal distribution. The extinction of the silversol is being measured and is proportional, according to working prescriptions, in the area of 0.001-0.5% CO. By wavelenghts below 500 mμ there is a considerable increase in the extinction. For this reason incasurements are made during short periods of light. With a ZEISS - filter S42 the incasurement sensitivity is about doubled. The method of CO determination is described in detail. -Author's abst translated AGC

691. Cotes, J.E.: An inter-laboratory study of the estimation of carbon monoxide. Ann. Occupat. Hyg. (London) 5:217-219 (Oct.-Dec.) 1962.

The author has been concerned with standardization of the measurement of pulmonary diffusing capacity of carbon monoxide by a single breath. From the instrumental point of view this requires the analysis of 2 gas mixtures, each containing helium and carbon monoxide. The accuracy of the resulting diffusing capacity depends on the accuracy of analysis of ratios of helium and CO concentrations in the 2 cylinders. Three test gas mixtures of known composition were decanted into smaller cylinders and then distributed in pairs to 21 laboratories where measurements of pulmonary diffusing capacity were being carried out. Complete results were received on 3 such pairs from 11 laboratories; these results were used to provide an estimate of the reproducibility and absolute accuracy of the measurement of carbon monoxide. For comparison, corresponding figures for helium were used for which the concentrations were higher. Helium is, in many ways, easier to analyze. Most of the laboratories from which results were obtained were staffed on a part-time basis under the supervision of a physician interested in the assessment of pulmonary function and not by physicists or chemists who might have been expected to have a more critical approach to the analysis. The range of results for each master cylinder has been described as a percentage of the mean concentration. For CO the range is 8.6-12.6%; the corresponding range for helium is 3.5-4.0%. Thus the scatter for CO is nearly 3 times that for helium. The results of the trial demonstrated that among physiological laboratories analyzing helium and CO, the reproducibility of individual estimates is relatively good. However, whereas there is little variation between laboratories in the analysis of helium concentrations and concentration ratios, there is considerable variation for CO and a tendency for laboratories to report consistently high or low ratios on successive occasions. These differences are reflected in the diffusing capacities which can be calculated from the data. - APCA 5351.

692. Dunham, A.R.: A simple carbon monoxide testing device. Gas Age Record 74:145-146 (Aug.) 1934.

A new combustion tester, a simple hand-operated means for drawing gases over color change test papers to detect carbon monoxide is discussed in this paper. Author states that this is an improvement over the commonly used Orsat apparatus to give rapid test results. - AGC

693. Evaluation of Detectors for Carbon Monoxide. U.S. Navy Toxicology Unit, National Naval Med. Center, Bethesda, Md., 1964, DDC AD 436828.

Seven (7) detection tube devices (A, B, C, D, E, F, G) for carbon monoxide were evaluated and six hundred (600) determinations were made using 467 detector tubes. Detector A is strictly a "safe-unsafe" indicator for CO and cannot be compared to the other "quantitative" detectors B, C, D, E, F, and G. It is compact, meets the manufacturer's specifications, and appears satisfactory for its intended use. Crew acceptance was in the following decreasing order of popularity: Detector B (most popular), Detector E, Detector D, and Detectors C, F, and G. In general, it should be pointed out that none of these tubes are intended to replace accurate laboratory analyses. At best, they are intended to give an approximation of the carbon monoxide concentration so that a rapid judgment can be made as to the potential health hazard and as to the precautionary measures that should be taken. All direct-reading tube detectors are subjective tests and depend on the man's ability to read instructions, ability to match colors or estimate length of stain, patience in checking instrument, and on his patience in taking a 2nd or 3rd pump stroke if indicated. Greater reliability can be obtained from all detectors if (1) sample flow rate and leakage rate are checked routinely and (2) only fresh detector tubes are used. - Authors' Sum.

694. Extremely Sensitive Carbon Monoxide Indicator Developed by Bureau Chemists. National Bureau of Standards Tech. News Bull. No. 354, 1946, 73 pp.

A colorimetric gel that will detect and estimate less than 1 part of carbon monoxide in 500 million parts of air, a sensitivity more than 100 times greater than that of former chemical indicators, has been announced. It will detect 0.001 percent by volume in less than 1 minute and determine physiologically significant amounts, 0.01 to 0.4 percent, in approximately 1 minute at ground level. It is possible to diagnose carbon monoxide poisoning by analyzing exhaled air instead of taking a blood sample. The indicating material, yellow in color, is a silica gel impregnated with a complex silico-molybdate compound and catalyzed by means of palladium in the form of the sulfate. It turns various shades of green and bluish green on exposure to carbon monoxide. The color response is a function of time by concentration of carbon monoxide. The indicator gel is sealed in a small glass 5 inches long and the diameter of a pencil, with protecting layers of pure silical gel in each end of the tube. To make a test, the ends of the tube are broken off and the tube inserted in an ordinary 2-ounce rubber aspirator bulb equipped with a rate-controlling valve. The air is drawn through the tube by squeezing the bulb once, and any color that develops is compared with a set of standard chips. For aircraft, table giving correction factors for altitude are provided. The tubes may be modified to detect other reducing gases and vapors, including many organic vapors. - BMB 1504

695. Faith, W.L.: Automobile exhaust control devices. J. APCA 13:33-35 and 39 (Jan.) 1963.

The nature of control devices depends on legislation set up by the California Motor Vehicle Control Board. The chemical requirements or emission standards for exhaust gases are: not over 1.5% by vol. carbon monoxide and 375 ppm. hydrocarbons. For crankcase blowby gases, hydrocarbon emissions are limited to 0.15% of the fuel supplied to the carburetor. These values reflect approximately 80% reduction of hydrocarbon emissions and 60% reduction of CO emissions. Specified criteria for life and safety devices, effect upon engine and vehicle performance, odor, noise, toxic, or noxious contaminants, the effect of these criteria, the degree, and the type of pollution required are discussed. - APCA 5185

696. Gofmekler, V.A.: The problem of sanitary protection of atmospheric air within the framework of the Council of Mutual Economic Aid. Gigiena i Sanitaria 29:104-106 (May) 1964. Published and Transl.for USDHEW, PHS and NSF, Washington, D. C., by the Israel Program for Scientific Translation, 1965. TT 65-50023/5.

This paper discusses the program planning meeting of the Council of Mutual Economic Aid. Among studies proposed for 1964-1965, is the investigation of the maximal allowable concentrations for 20 combinations of substances in the atmospheric air, which includes carbon monoxide. The combination of SO_2 and CO will be investigated by scientists in Bulgaria. Development of new methods of investigation of atmospheric contamination are contemplated. Along with the development of chemical methods of investigation, greater attention will be paid to physico-chemical methods. The possibility of determination of CO by spectrophotometric methods is being studied in Czechoslovakia. Development of new automatic instruments for the registration of atmospheric contaminants is planned in the German Democratic Republic and in Poland. New methods of sample collection are developed in the U.S.S.R. - AGC

697. Grant, G.A., Katz, M., and Haines, R.L.: A modified iodine pentoxide method for the determination of carbon monoxide. Canadian J. Technology 29:43, 1951.

The iodine pentoxide method for the estimation of carbon monoxide has been improved by refinements in the design of the apparatus and by the spectrophotometric estimation of the liberated iodine. The improved apparatus and methods are demonstrated by estimating the carbon monoxide concentration in 10 known mixtures of carbon monoxide and nitrogen, ranging in concentration from 0.09 to 0.0007% carbon monoxide. - Authors' abst.

698. Greig, J.D.: A comparison of carbon monoxide detectors having different colorimetric principles under underground conditions. J. Mine Vent. Soc. (S. Africa) 10:77-85 (April) 1957.

The performance of 3 different types of carbon monoxide detectors was checked over a range of temperature, humidity, and pressure, covering underground operating conditions. All 3 types were found to be satisfactory in the absence of other interfering gases. The effects of other gases on the detectors was then investigated. Of the gases tested, only nitrogen oxides showed serious interference. In concentrations of nitrogen oxides of the order of 0.003% and higher, indicator gels depending on the reduction of a yellow silico-molybdate complex are affected to a large extent while those based on the production of iodine from iodine pentoxide or the reduction of a palladesulfite were affected to a much lesser degree. APCA - 1514

699. Hagen, D.F., and Holiday, G.W.: The effects of engine operating and design variables on exhaust emission. SAE Paper 486C. Presented at the Combined National Automobile and Production Meetings of the SAE, March 12-16, 1962, pp. 41.

To determine the influence of engine variables on the composition of exhaust gas, engine dynamometer tests were conducted on single and multi-cylinder reciprocating engines. The following engine variables were investigated: air-fuel ratio, power output, engine speed, spark timing, exhaust back pressure, valve overlap, combustion chamber deposits, and intake manifold pressure.

Hydrocarbon concentrations were found to be considerably affected by changes in air-fuel ratio, spark timing, intake manifold pressure, and combustion chamber deposits. Somewhat less change in hydrocarbon concentration was obtained by varying valve overlap and engine speed. Changes in engine power output and exhaust back pressure had little effect on hydrocarbon concentrations.

Carbon monoxide concentrations were principally affected by changes in the air-fuel ratio. No other variables affected carbon monoxide concentration except where air-fuel ratio was indirectly influenced.

The influence of changes in the variables on hydrocarbon and carbon monoxide emissions in pounds per hour was also determined.

Vehicles were tested on the road and chassis dynamometer to investigate the effect of air-fuel ratio, spark timing, and valve overlap on hydrocarbon and carbon monoxide concentrations. Carburetion leaning, spark timing retardation and reduction of valve overlap produced concentration reductions in line with those predicted from engine dynamometer studies. - Authors' Abst.

700. Hellmann, C.S.: Initial Survey of Published Work in the Field of Carbon Monoxide or Other Diatomic Molecular Gases with Particular Reference to Possible Sensing Systems. Douglas Aircraft Co., Inc., Calif., Sept. 25, 1961, 75 pp. DDC AD 277157.

The provision of a carbon monoxide sensor as a novel and necessary new item of research equipment is discussed. Primary emphasis is placed on possible means of achieving a practical sensor design; appendices include the basic derivations and terminology peculiar to the fields of chemical and molecular physics, with accent on molecular spectrography.

Bio-physical aspects and other possible uses are noted. A complete table of constants as a possible design basis is included in the main text and amplified in the appendices. - Author's Abst.

701. Hochheiser, S., Storlazzi, M., and Basbagill, W.J.: Use of a mobile laboratory in air pollution studies. Amer. Indust. Hyg. A. J. 26:77-83 (Jan.-Feb.) 1965.

Measurements of gaseous and particulate atmospheric pollutants and meteorological conditions are performed using sampling and analytical equipment contained in a combination air sampling-analysis laboratory. The mobile unit consists of a semi-trailer containing automatic continuous air monitoring equipment, manual air sampling equipment as well as laboratory instruments and utilities. It was designed to provide comprehensive information on air quality, evaluate manual and automatic instrumental methods of air analysis using atmospheric samples and to demonstrate the technology available pertaining to the measurement of air pollution. The unit is operated at a strategic urban location for about 4 to 6 weeks, where atmospheric sulfur dioxide, nitrogen dioxide, oxidants, carbon monoxide, carbon dioxide, hydrocarbons, wind speed and direction, temperature, humidity, and solar radiation are determined using automatic monitoring equipment. Suspended atmospheric particulates are determined using a sequential sampler and a 24-hour sampler. Short-term manual samples are collected 4 times daily for analysis of sulfur dioxide, nitric oxide, nitrogen dioxide, oxidants, carbon monoxide and aldehydes using a variety of sampling and analytical methods for each specific pollutant. The meteorological data obtained are compared with observations made at the airport weather bureau stations. The results obtained by simultaneous determination of a specific pollutant using a variety of manual and instrumental methods are compared. Diurnal variation among pollutant levels and meteorology is determined.

These studies were conducted by the USPHS, Division of Air Pollution, Technical Assistance Branch with the participation of State and local air pollution control agencies primarily to fill the need for more information on community air pollution and methods of measurement. - Authors' abstract

702. Huber, E.W.: CO-formation in motor vehicle engines. Automobiltechnische Zeitschrift (ATZ) 62:320-325 (Dec.) 1960.

A study of whether and under what conditions the CO-formation of an engine can be reduced is discussed in this paper. Although the same CO-content is obtained with a good mixture with the same air ratio is as with a bad mixture, the fuel portion in the mixture and thus the CO-content can be reduced considerably with a good mixture. A partial-load operation is possible with a complete fuel consumption which reduces the CO-content to about one-tenth of that of the customary throttle control. By improving the mixing equipment and the course of combustion, the operating conditions, possible on the test stand, might also be realized in industry.

Tests with a compression-ignition engine with diesel fuel and with a gasoline operation in the case of excess of fuel, as well as with an NSU Wankel engine are reported. - Author's Abst. translated-AGC

703. Johnson, B.L., and Strong, A.A.: The Design of an Automatic Control System for Laboratory Produced Automobile Exhaust Concentrations. Presented at the 58th APCA Annual Meeting, June 20-24, 1965, Toronto, Canada.

A control system for regulation of the carbon monoxide concentrations in diluted laboratory produced automobile exhaust is described. The system samples one complete cycle of the cyclic diluted automobile exhaust, integrates this value, and passes the integrated sample to a carbon monoxide analyzer. Correction system then effects carbon monoxide concentration changes through use of motor driven needle valves. - Authors' Abst.

704. Kattwinkel, R.: Determination of carbon monoxide with iodine pentoxide. Glückauf. 77:22-23, 1941.

An improvement on the apparatus of Winter and Braukmann is described in which the gas is passed through the iodine pentoxide instead of over it, and an aluminum-block oven is substituted for the oil bath. A tube of NCT_3 steel is used in place of a quartz combustion tube for holding the copper oxide. - BMB 1437

705. Katz, S.H., Reynolds, D.A., Frevert, H.W., and Bloomfield, J.J.: A Carbon Monoxide Recorder and Alarm. USBM TP355, 1926, pp. 35.

The apparatus described has been developed to analyze and record automatically carbon monoxide when present in very low concentrations, especially that in the atmospheres of vehicular tunnels. It is based on the thermoelectric effect produced in differential thermocouples when air containing CO is passed through a catalyst of hopcalite surrounding the hot junctions of the thermocouples.

Cells holding hopcalite catalyst with differential couples of 6, 12, 24, 48, and 96 pairs of couples were made. These were placed in a constant-temperature environment, usually saturated steam, and the couples were connected electrically with a recording potentiometer.

A complete unit CO recorder included a motor-driven blower for the gases, a gas cleaner and purifier of sulphuric acid, caustic soda material, activated charcoal, filters of absorbent cotton, and fused calcium chloride drier, a flow meter arranged to maintain a constant rate of flow of gas through the cell, and copper coils for bringing the gases to the temperature of the cell environment before entering the cell. After passing through the cell the gases were wasted through a guard of fused calcium chloride to prevent entrance of water vapor. The recording potentiometer included mechanism for closing an electric circuit to ring a warning bell or operate signals as long as the CO exceeds a predetermined concentration.

This method of CO analysis is the most accurate and sensitive yet devised for small concentrations of CO in air. A sensitivity of 1 part per million is readily attained. - Authors' Sum.

706. Klein, W.J.: Detection of carbon monoxide by H. T. A. gas-leak indicator. Het Gas 68:73-75, 1948.

The essential parts of this apparatus are a spongy disk, an elastic membrane, a disk of filter paper, a cover with a small hole flanked by two lintiform protuberances, the whole assembled in the order named in a threaded ring and a flask containing a solution of palladium chloride in a mixture of water and acetone. The cover is the same color as this solution. The tints of the two protuberances correspond to those taken by the solution in contact with an atmosphere containing 0.05 and 0.1 percent CO, respectively. The part of the filter paper opposite the hole in the cover is moistened with the solution of palladium chloride. The apparatus is then exposed to the atmosphere under suspicion. The tint of the filter paper when compared with the colors of the cover and the two protuberances gives an indication of the CO content of the atmosphere. Comparison of the results with those obtained with the Drager instrument is satisfactory. The shape of the two protuberances somewhat hinders comparison of the tints. The possibility of juxtaposition of the colors would have been preferable. The prospectus accompanying the apparatus indicates a CO tolerance a little too high for the worker. The reagent is guaranteed only for 4 months. Aging does not have any visible effect, and the user is advised to renew the reagent periodically. - BMB 1574

707. Korth, W.; Dynamic irradiation chamber tests of automotive exhaust. PHS No. 999-AP-5 U.S.D.H.E.W., PHS, Div. of Air Pollution, Cincinnati, Ohio. (Nov.) 1963 - 54 pages.

As part of an intensive study by government and private agencies the U. S. PHS has built an irradiation chamber facility for investigation of irradiated auto exhaust under mixing conditions similar to those in the atmosphere. The facility consists of a programed continuous-cycling chassis dynamometer, an exhaust dilution-air purification system, 2 irradiation chambers, and exposure facilities for evaluation of bacteria kill, plant damage, and various effects on small animals. Of the 3 variables studied during the 1st test series, the exhaust concentration at the start of irradiation appeared to produce the most significant effects. Fuel composition had a lesser influence. Very little difference was noted in the effects produced at 2 different average irradiation times. - APCA 6065

708. Lamb, A.B., and Larson, A.T.: The rapid determination of carbon monoxide in air. J. Amer. Chem. Soc. 41:1908-1921 (July-Dec.) 1919.

The necessity for an accurate and rapid method for the analysis of dilute carbon monoxide air mixtures in the study of gas mask absorbents for carbon monoxide has been explained.

Two thermometric methods answering this requirement have been described. In the first method the gas mixture is passed over a platinum wire heated to redness and the carbon monoxide is partially burned in contact with it. The gas mixture is then freed of carbon monoxide by passing through heated copper oxide and is brought back in a thermostat over another identical platinum wire heated by the same electric current. The first wire is the hotter because of the combustion which occurs on it--and the resultant relative change in the resistance of the two wires serves as a measure of the concentration of the carbon monoxide. In the second method the mixture is passed through a plantinized, plantimum catalyst when the carbon monoxide is completely burnt. The temperature rise is measured by a thermoelement and indicates the concentrations of the carbon monoxide.

Both methods are rapid. The latter is particularly accurate, easy to install and to operate. With reasonable precautions the activity of its catalyst remains constant so that machines have been in constant satisfactory operation for many weeks at a time. Being very nearly instantaneous these methods are particularly useful for continuous analysis of a changing gas mixture. Attempts to apply them to the analysis of flue and combustion gases are already under way. - Authors' Sum.

709. Lastochkin, P.N.: A new method and apparatus for the determination of carbon monoxide in the air. Gigiena i Epidemiologiya, No. 1, pp. 9-12, 1928. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 1, 1960, pp. 143-147, CFSTI-TT-60-21049, U.S. Dept. of Commerce, Springfield, Va.

A method and apparatus for the determination of CO in the air in general and in the air of industrial premises in particular are described in detail. The method and apparatus are based on the property of a mixture of metals known as hopcalite (MnO_2, CuO, Co_2O_3 and Ag_2O) to catalytically oxidize CO contained in the air to CO_2. The author states that any of the determination procedures described in the text including conversion of the thermocouple and expansion plate effects into sound or light waves can be used for any CO concentration. Hopcalite of higher catalytic activity increases the sensitivity of the apparatus. - AGC

710. Lindsley, C.H., and Yoe, J.H.: Acidimetric method for determination of carbon monoxide in air. Anal. Chem. 21:513-515 (April) 1949.

An acidimetric method for the determination of low concentration of carbon monoxide in air is described. The monoxide is oxidized, resulting dioxide absorbed in an excess of barium hydroxide solution, and excess alkali measured by titration with a standard solution of oxalic acid. Appreciable error may be introduced by the use of phenolphthalein as indicator (color change at pH 7.8 to 8.0), owing to action of acid on the finely divided barium carbonate suspension. The magnitude of this error was determined by using thymolphthalein (color change at pH 9.0); allowance is made by a correction of + 0.001%. Comparison with values of the iodine pentoxide method and with known values for samples supplied by National Bureau of Standards showed results accurate within 0.001%. - Authors' Abst.

711. Lodge, J.P., Jr., Frank, E.R., and Huitt, H.A.: Studies on a Simple Carbon Dioxide Analyzer. Presented at the 55th APCA Annual Meeting, Chicago, Ill., May 20-24, 1962.

Studies have been continued on a device to determine atmospheric carbon dioxide by measuring the pH of an aerated suspension of calcium carbonate. Experiments have been made to determine the limiting sensitivity, the reproducibility, and the temperature coefficient of the system. The air of the studies is to develop an instrument competitive with the more accurate non-dispersive infra-red analyzers. The possibility of using very low cost recorders has also been explored in order to produce the least expensive possible instrument. - Authors' Abst.

712. Löhner, K., Muller, H., Luther, H., and Ihrig, H.: Carbon monoxide content of the exhaust gases of automobile combustion engines. Automobiltechnische Zeitschrift (ATZ) 62:311-320 (Dec.) 1960.

After a description of the testing installation of a continuous CO analysis on the basis of infrared absorption, the results of tests with regard to CO content in the exhaust of a diesel engine for motor vehicles and of four Otto engines are given. In addition to data from stationary tests of characteristics, the study reports on the behavior at accelleration and decelleration, and at long-distance travel during a driving test. The scattering ranges of the test data and the related variation of the CO emission of a normal engine are given. - Authors' Abst. translated-AGC

713. Lysyj, I., Zarembo, J.E., and Hanley, A.: Rapid method for determination of small amounts of carbon monoxide in gas mixtures. Anal. Chem. 31:902-904 (May) 1959.

The determination of small amounts of carbon monoxide in gas mixtures has great industrial importance. Because of its high toxicity, traces must be determined in many industrial processes, mine atmospheres, and exhaust gases. A rapid and simple method for the determination of carbon monoxide in gas mixtures converts carbon monoxide to carbon dioxide by using decomposed silver permanganate as a catalyst. The carbon dioxide formed is absorbed in an Ascarite tube and determined gravimetrically. With 500 ml. gas samples, concentrations of carbon monoxide in the order of 0.1 to 1.5% can be determined. By increasing the sample size the lower limits of this method can be extended. The method is well suited to working conditions encountered in a plant control laboratory. - APCA 2467

714. Middleton, J.T.: Criteria for certification of motor vehicle pollution control devices in California. J. APCA 13:78-80 (Feb.) 1963.

The motor vehicle control act stipulates that motor vehicle emission shall be controlled for those sources which the State has established standards. The certification of devices to control motor vehicle pollution emissions has been made possible through the adoption by the Motor Vehicle Pollution Control Board criteria and test procedures. It is estimated that crankcase emission control systems are installed on approximately 10% of the State's 8 million motor vehicles and effect a 2-1/2% reduction in hydrocarbon emissions. Criteria for crankcase emission control systems and exhaust emission control are discussed. - APCA 5499

715. Minchin, L.T.: Detection of carbon monoxide or town gas in air. Gas J. 251:100-105, 1947.

Methods are dealt with involving palladium compounds, particularly the new Ministry of Supply method, which uses silica gel impregnated with [illegible] yellow potassium pallo-sulfite, and a similar type developed in America which uses palladium-molybdenum complex on silica gel. A description is given of a new double-aspirator testing device, which can conveniently be used with either the palladium paper or the M. of S. tube. - BMB 1546

716. Mokhov, L.A., and Demidov, A.V.: Determination of carbon monoxide in the air by means of an indicator tube. Laboratornoe Delo, Vol. 3, No. 1, pp. 48-50, 1957. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 1, 1960, pp. 165-167, CFSTI-TT-60-21049, U.S. Dept. of Commerce, Springfield, Va.

Many methods have been proposed for the determination of carbon monoxide in the air. Nearly all are based on the reducing property of CO. The method based on the reduction of palladium salts, producing a blackening of the solution and of the filter paper saturated with the palladium salt solution is the one used most frequently. Many of the palladium salt reduction methods have shortcomings such as low sensitivity, require relatively large volumes of air for analysis, their indicators lack stability, the time needed for the color developing is too long, etc.

The method described in this paper is rapid, the reagents employed are stable, and the reaction-color develops in a short time. The principle of the method is the reduction of palladium sulfate by CO. Control tests established that palladium sulfate is reduced more rapidly than any other palladium salt. Ammonium sulfate, one of the components of the indicator, stabilizes it, and ammonium molybdate increases the sensitivity of the reagent. Silica-gel is used as the indicator base. The final product is introduced into a glass indicator tube and the air aspirated through it in a given volume. - Authors' Introduction

717. Moore, H.E., and Schwartz, R.G.: Development of Alarm, carbon monoxide, Automatic, E23(U) Chemical Corps, Chem. & Radiol. Lab., Army Chemical Center, Md., Aug. 9, 1955, 32 pp. DDC AD 72078.

The object of this work was to develop an automatic carbon monoxide alarm meeting the revised military characteristics as approved by CCTC item 2296. The E23 carbon monoxide alarm was developed based on the Hopcalite principle. It is 18-1/4 inches high, 11 inches wide, and 12-1/4 inches deep and weighes 40-1/2 pounds. The alarm responds to 200 p.p.m. of CO in approximately 65 seconds, giving both an audible and visual alarm. Higher concentrations are detected in a shorter time. The instrument will indicate on a meter the presence of concentrations under 200 p.p.m., but is not set to give an alarm with these possible background concentrations. The E23 carbon monoxide alarm (appendix) is satisfactory for military purposes. It is portable and operates off 24-volts a.c. or d.c. and 110-volts a.c. It is capable of operation under cold weather conditions and is sufficiently shock-mounted to withstand moderate rough handling, such as transport in a truck or jeep over rough terrain. The instrument must be given proper maintenance, including periodic changes of catalyst and replacement of brushes in the blower motor, to insure reliable operation (appendix). - Authors' Abst.

718. New techniques for carbon monoxide detection. Gas World 162:491-492 (Oct. 30) 1965.

For some years, the "CO-test" pallado-sulphite silica gel tube has been used for this purpose. This tube contains a yellow column of granules with a white protective column on each side. If a known column of air (usually 120 cc) is passed through this column, any CO present will form a dark ring in the yellow column; from the thickness of the ring the amount of CO present can be deduced. At a low rate of flow it is confired to the place where it enters. A special aspirator is therefore necessary. For the past 17 years Combustion Instruments, Ltd., have been producing a double aspirator (Minchin pattern) which successfully performed this function. The double aspirator has been superseded now by a much simpler and cheaper device. The operation of the 'Combist' involves allowing a weight-loaded piston to descend, drawing in the sample through the CO-test tube. A small orifice at the top of the cylinder controls the rate of flow, so that each complete stroke of the piston occupies about 2 minutes. Small amounts of other gases (except H_2S) do not interfere. If it is desired to exclude the effect of H_2S another variant known as 'DUCO-CO-test' can be supplied which contains a lead acetate filter to remove it. Large amounts of hydrogen or unsaturated hydrocarbons (5 to 10 times greater than CO) cause serious masking: the whole column tends to darken, making it difficult to measure the band caused by the CO.

719. Oppenheim, U.P.: Experimental Verification of Theoretical Relations Between Total Gas Absorptivities and Total Gas Emissivities for CO. Guggenheim Jet Propulsion Center, Calif. Inst. of Technol., Pasadena, Oct. 1958, 14 pp., 4 Fig. DDC AD 204287.

An experimental study was carried out for the purpose of verifying theoretical predictions concerning the relations between total absorptivities and total emissivities for transparent gases. The experimental conditions were designed in such a way as to permit a direct check of theoretical relations derived for (a) non-overlapping dispersion lines and (b) spectral lines with sufficient pressure broadening to permit neglect of the rotational fine structure. A comparison between the emissivities derived from absorptivity measurements and emissivities calculated from the spectroscopic constants of CO shows good agreement (within 20% for most of the temperature range).

The apparatus for the measurement of total gas absorptivities is described. Results for total absorptivities of carbon monoxide measured at temperatures between 300 and 500°K are given and total emissivities were calculated in the temperature range of 300 to 1600°K. The range of total gas pressure is 0 to 515 psia. - Author's Abst.

719a Optico-Acoustic Gas Analyzers of Carbon Monoxide, Carbon Dioxide and Methane, OA_{2109}, OA_{2209}, OA_{2309}. Description and Instructions For Assembling and Operation, No 2266-2292 IM. Translated from Russian by JPRS. February 1965. U.S. Dept. of Commerce CFSTI-TT-30309.

This is a translation of a set of instructions concerning gas analyzers which are stationary, automatic-recording instruments and are designed for continuous measurement of CO, CO_2, and methane.

720. Ponnels, N.E.: CO boiler pays off in fuel savings and produces zero CO. ASME Annual Meeting Paper No. 56-A198, Mech. Eng. 79:590 (June) 1957.

The CO boiler was developed to effect substantial fuel savings through the combustion of the carbon monoxide content of catalytic cracking unit regenerator flue gases. The ability of the CO boiler to burn the regenerator flue gas to zero CO makes it an effective air pollution control device in areas where local conditions require limitations on emission CO to the atmosphere. Operation of the first CO boiler at Sinclair Refining Company's Houston refinery has been successful, resulting in complete combustion of CO to CO_2 and effecting substantial fuel savings. Approximately 180 million Btu/hr. are recovered from the sensible heat of the carbon monoxide gas, and 140 million Btu/hr. from the combustion of the carbon monoxide for a total waste heat recovery of 320 million Btu/hr. - APCA 1411.

721. Procedures and Analytical Methods for Determining Toxic Gases Produced by Synthetic Materials. Procedures for Flash-Ignition and Self-Ignition Temperature Determinations. United States Testing Company, Inc., Hoboken, N.J., Dec. 1963, 49 pp. DDC AD 297457.

Equipment, procedures and analytical methods for determining the nature and concentration of toxic gases produced when synthetic materials are subjected to flammability tests are described. A method for flash-ignition temperature determination is given. The necessary equipment and a procedure for determining the self-ignition temperature of heat resistant material is described. - Authors' Abst.

722. Reid, R.S., Mingle, J.G., and Paul, W.H.: Oxides of nitrogen from air added in exhaust ports. Presented at Automotive Eng. Congress, Detroit, Mich., Jan. 1966, ASE Paper No. 660115.

This paper presents the results of a study made to examine quantitatively the oxides of nitrogen in the exhaust of an internal combustion engine installed in a passenger car. The effects of adding secondary air in exhaust ports, with both a rich and lean carburetor, and for steady-state conditions, are reported. The addition of secondary air at the exhaust ports of an automotive engine is one method employed to reduce the exhaust concentrations of carbon monoxide (CO) and hydrocarbons, major contributions to atmospheric air pollution. Experimental setup and procedures are explained. - Authors' Abst.

723. Serruys, M.: Noxious materials in exhaust gases of automobiles. Chimie et Industrie 82:663-675 (Nov.) 1959.

The author studies the nature and importance of atmospheric pollution particularly by exhaust gases from combustion engines and Diesel engines, under all "working conditions".

He then deals with methods used for reducing the amount of unburnt gases and comes to the conclusion that the use of a device (such as the "M.S." regulator for example) which improves the conditions of combustion inside the motor is preferable to any other solution. - Author's Abst.

724. Serruys, M.: New advances in cleaning automotive exhaust gases. Rev. Pollution Atmospheric (APPA) 5:171-192, 1963.

The toxicity of automotive air pollutants (CO and C_6H_{14}) are discussed in this paper. The author, who stresses the importance of reducing the CO content primarily because of its effect on health, describes following control methods for the reduction of CO: Oxydation of exhaust gases after leaving the engine, and the improvement of combustion inside the engine.

By certain adjustments in the carburetor, using a MSH-D_2 respectively -D_3, and implement in the exhaust pipe of the engine named but not described, allegedly, achieves considerable reduction of CO- and C_6H_{14}-contents in the exhaust gases. By this process the health effect and economic benefit (saving of fuel) are both accomplished.

A review of results of experiments with engines with and without MSH-implements type D_2 show the values for CO in percentages and C_6H_{14} in ppm. According to these statistics CO-values of engines with the MSH-D_2- instrument are considerably lower than those without the MSH-D_2- instrument. There is also a decrease of the C_6H_{14}-values of engines with the MSH-D_2- instrument, but not as clearly shown as the CO-values. Although the equipment mentioned above means an additional load for the engine the CO contents are less than 0.2% and the C_6H_{14}-contents are below 250. - Translation from Abstract in German-AGC

725. Smith, A.M., and Struck, J.H.: A simplified method for characterizing a motor vehicle's exhaust emissions. J. APCA 11:251-253 and 258 (May) 1961

An absolute technique has been developed for characterizing the exhaust emissions of an automobile as operated through a complete traffic cycle. The technique involves the collection of all of the exhaust gases in an evacuated plastic bag. Subsequent measurements of the composition and volume of this total sample can be accomplished using any available laboratory measuring technique.

Plastic bags of Mylar film were shown to result in no change in hydrocarbon, carbon monoxide, or carbon dioxide concentrations for one hour after bag filling. Plastic bags made of polyethylene are considered usable if measurements are made immediately after filling the bag.

The inherent accuracy, utility, and simplicity of this technique will eliminate many of the current measurement problems now plaguing those involved in evaluating automobile exhaust emissions. - Authors' Sum.

726. Smith, R., Rose, A.H., Jr., and Kruse, R.E.: An auto-exhaust proportional sampler. Internat. J. Air & Water Poll. 8:427-440 (Sept.) 1964.

The development of an instrument to obtain a proportional sample of auto exhaust gas is described. The proportional sampler is a servo device, which controls the flow of exhaust gas in the sampling line to maintain it at a fixed percentage of the carburetor air flow rate. The flow rates in carburetor and sample line are measured continuously by means of laminar-flow elements and associated pressure-difference transducers. The proportional sampler is used in a vehicle on the road to provide a representative sample of exhaust gas, which is then analyzed to obtain mole-fraction measurements of various air contaminants in the vehicle exhaust. The total volume of air entering the carburetor is also measured. The values for total air volume entering the carburetor and mole fraction of contaminants are used to calculate the emission rates in pounds of each air contaminant emitted per vehicle mile traveled. - Authors' Abst.

727. Sourirajan, S., and Accomazzo, M.A.: The application of the copper oxide alumina catalyst for air pollution control. Canadian J. Chem. Eng. (Ottawa) 39:88-93 (April) 1961.

The copper oxide alumina catalyst developed in this program of investigations has been found to be efficient for the continuous and simultaneous removal of hydrocarbons and carbon monoxide present in auto exhaust gases. The catalyst showed no deterioration in performance even after 100 hours of continuous service in conjunction with exhaust gases from an auto engine run on leaded gasoline fuel. Instantaneous catalyst temperatures of the order of 900°C. have been encountered in this work with no deleterious effect on the subsequent effectiveness of the catalyst. By proper choice of the converter design, the heat liberated during the reaction can be advantageously used to maintain the full effectiveness of the catalyst under all conditions of engine operation encountered in normal practice. Aside from the experiments with the auto exhaust gases reported, the copper oxide alumina catalyst developed in this work has possible application in any air pollution control device concerned with the removal of hydrocarbons and carbon monoxide present in low concentrations by oxidation. - APCA 3704

728. Stern, A.C.: Prospects for exhaust control by engine modification. J. APCA 13:91-92 (Feb.) 1963.

Of the three paths to the prevention of the emission of combustibles from motor vehicle exhaust, two seem to be mere stopgaps. Improving the performance of the conventional rich-mixture engine by gadgeteering the carburetor and the distributor is self-limiting in its possibilities for emission reduction by the fact that even when improved there is insufficient air to burn the fuel supplied. To use afterburners is to admit failure in engine design. Only the path of designing completeness of combustion into the engine itself has long term attractiveness as a means for control. - Author's Conclusion.

729. Sweeney, M.P.: Exhaust control devices. J. APCA 15:13-18 (Jan.) 1965.

Author summarizes the latest current developments in the area of exhaust control devices, briefly reviews procedures developed and used, and reports leading up to approval. The effort of the State of California has resulted in approving device systems for application to 140 cubic inch displacement and larger passenger automobiles and pickup trucks. The California law has been activated for new cars and these will be mandatory for 1966 models. - AGC

730. Teague, M.C.: The determination of carbon monoxide in air contaminated with motor exhaust gas. J. Indust. & Eng. Chem. 12:964-968 (Oct.) 1920.

The iodine pentoxide method for determining low concentrations of carbon monoxide has been investigated with reference to its use with dilute motor exhaust gas. The type of apparatus heretofore used was found to give appreciably high results owing to the presence of small amounts of unburned gasoline. A new iodine pentoxide apparatus (Type II) has therefore been developed. All of the interfering gases are first removed at the temperature of liquid air. This method has been found quite satisfactory for determining carbon monoxide in small quantities in the presence of gasoline vapor.

A portable iodine pentoxide apparatus has been designed which should permit a determination to be made in 15 minutes with an accuracy of from 0.003 to 0.005 per cent carbon monoxide (0.3 to 0.5 part in 10,000). - Author's Sum.

731. Van Slyke, D.D.: Studies of acidosis. II. A method for the determination of carbon dioxide and carbonates in solution. J. Biol. Chem. 30:347-368, 1917.

A simple one piece apparatus is described for determination of the carbon dioxide or carbonate content of water solutions. It has been designed especially for anlaysis of 1 cc. samples of blood plasma, but is applicable to water solutions in general as well as to the determination of dissolved gases other than carbon dioxide.

The entire analysis is performed at room temperature, requires about 3 minutes, and without especial precautions is capable of accuracy to within 1 per cent of the amount determined.

A micro-apparatus designed on a similar principle is described. With it the carbon dioxide content of 0.2 cc. of plasma can be determined with an accuracy of 1 volume per cent. - Author's Sum.

732. Van Slyke, D.D.: Gasometric determination of the oxygen and hemoglobin of blood. J. Biol. Chem. 33:127-132, 1918.

The apparatus described by Van Slyke in J. Biol. Chem. 30:347, 1917, for determining the carbonic acid content of plasma may be used with equal facility for determining the oxygen content and the oxygen-binding capacity (hemoglobin) of blood. The oxygen is set free from combination with hemoglobin within the apparatus by addition of ferricyanide, is extracted in a Toricellian vacuum, and measured at atmospheric pressure, a few minutes sufficing for an accurate determination. - Author's Sum.

733. Vylomov, V.S.: Indicator for carbon monoxide. Zavodskaya Lab. 14: 1134-1135, 1948.

In the compact, portable detector described, the carbon monoxide contained in a sample of air is caused to react with hopcalite, the heat of the reaction causing a rise in temperature, which is measured with a number of thermocouples connected in series. The device can also be used to give approximate quantitative determinations. - BMB 1589

734. Yarrow, T.J., Jr.: Chronic carbon monoxide poisoning, With report of an illustrative case. New York Med. J. 71:496-498 (April) 1900.

Author states that due to the similarity of chronic CO poisoning with various other conditions it is probable that many cases of this toxaemia escapes recognition. The object of this paper is to call attention to this danger and to emphasize the use of the spectroscope in cases of obscure affections. Several chemical test methods are reviewed, however it is emphasized that the delicacy of the spectroscope surpasses those chemical tests. - AGC

SAMPLING AND NETWORK OPERATIONS

735. **Air Monitors Swing into Action.** Chem. Eng. 69:52,54 (Feb. 5) 1962.

San Francisco's new atmosphere monitoring station at Union Sq. opens a major nationwide study of how auto exhaust gases may be affecting people's health in urban areas. Gas analyzer stations in 6 cities will operate continuously, gathering data on air pollution for study that may determine extent of health hazard from auto exhaust. Data contributed by the San Francisco monitor will be supplemented by similar data from new stations at Cincinnati, Chicago, Philadelphia, New Orleans, and Washingtn, D. C. as well as from older stations at Los Angeles and Detroit. While the entire instrument assembly was custom built to USPHS specification, the carbon monoxide analyzer and the hydrocarbon detector incorporate new ideas. Other analyzer features are discussed in detail. -APCA 4656

736. Alekseyeva, M.U., and Khrustaleva, VA.: A study of automatic exhaust gases. Gigiena i Sanitaria 25:10-14, 1960. In: Levine, B.S. (translator and editor): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. U.S. Dept. of Commerce OTS 62-11103, Washington, D.C., Vol. 7, 1962, pp. 279-283.

Authors investigated the organic substances in the atmospheric air in sidewalks during heavy automobile traffic. Quantitative determinations were made of formaldehyde, acrolein, ketones, unsaturated and aromatic hydrocarbons, and also of the total amounts of carbon and carbon monoxide. Samples were collected by the vacuum method into special pipettes of 0.5-1 li capacity at a distance of 0.5m from the exhaust pipes of small "Volga", ZIL -110 and "Pobeda" types of automobiles burning high octane gasoline, GAZ -51 trucks burning low octane gasoline, and ZIL buses burning Diesel oil. Results of more than 100 analyses are listed. Data listed in the tables point to the need for systematic sanitary inspection of automobiles and examination of city air for concentrations of carbon monoxide and other organic substances. -AGC.

737. Basbagill, W.J., and Dallas, J.L.: Air Quality in Boston, Mass. Nov.-Dec. 1963. U.S. DHEW, PHS, Div. of Air Pollution, Cincinnati, Ohio, Nov. 1964.

Measurements were made using the IR analyzer in TAB's Mobile lab. Hourly average concentrations ranged from 1.0 to 8.4 ppm CO. Relationship of CO to wind speed and time of day are listed. - LEPS

738. Cambier, R., and Marcy, F.: On the composition of the air in the streets of Paris. Compt. rend., Acad. Sc. 186:918-921, 1928.

A further contribution on the content of carbon monoxide of the air of the streets of Paris. It was found usually to be below 1 part in 100,000 and to rise at the highest to 50 parts per 100,000 (a single observation). The amount rose to 10 parts in the most frequented streets and in particular at points where the traffic is held up by police control and the engines of motors are left running. Despite the immense increase of motor traffic in Paris, the amount of CO_2 in the air was found hardly to exceed the amount fixed by Albert Levy in 1877, namely, 32 parts per 100,000, the largest amount found being 60 parts per 100,000 at a point where 2,600 vehicles were passing per hour. - BMB 397

739. Carbon monoxide on the highway. Scientific American 212:52-57 (May) 1965.

Reported in this review is a study by A.J. Haagen-Smit and T.W. Latham who investigated concentrations of CO encountered during eight trips along the commuter route between Pasadena and Los Angeles during peak traffic hours, CO levels near the drives were recorded. The concentration of CO fumes are found to be such as to present a possible danger to the health and driving abilities of the commuter. Normally Los Angeles air contains 10 to 12 parts of carbon monoxide per million parts of air. According to the California State Department of Health, 30 ppm is an "adverse" level and 30 ppm for eight hours or 120 ppm for one hour is a "serious level of pollution." The level measured by the two investigators was 37 ppm; in slow and heavy traffic the average was 54 ppm, with peaks as high as 120 ppm. The level dropped rapidly on less traveled streets but rose again at stop signals. According to Haagen-Smit, two hours in bad traffic would bring the CO concentration in a commuter's hemoglobin to the "serious" level. Studies of the effect of CO on a person's alertness and driving skill are recommended. Automobile exhaust-control devices, mandatory in California beginning with 1966 models, are expected to significantly lower the incidence of smog in general as well as the CO level in particular. - AGC

740. Castrop, V.J., Stephens, J.F., and Patty, F.A.: A comparison of carbon monoxide concentrations in Detroit and Los Angeles. Amer. Indust. Hyg. Ass. Quart. 16:225-229 (Sept.) 1955.

Sampling at 5 feet above street level from an automobile while moving in traffic gave peak values in Detroit of 80, 40, and 50 ppm in traffic subjectively assessed as heavy, medium, and light, respectively. Mean values for the same traffic categories were 28.9, 12.3, and 6.9 ppm. Data collected in Sept., 1952 and Oct., 1953. Similar sampling in Los Angeles gave peak values of 160, 85, and 60 ppm for heavy, medium, and light traffic. Mean values were 58.0, 27.5, and 11.8 ppm. Sampler only described as "a carbon monoxide indicator", with a double scale microammeter reading 0-100 ppm and 0-1000 ppm.

The levels are not significantly higher than those reported by investigators in 1926 (Philadelphia) and 1928 (Chicago) in spite of the increase in traffic density. This is attributed to increased engine efficiency, and lower CO output per vehicle mile.

CO determinations were also made at about 150 feet above main thoroughfares in the two cities. Detroit range 0.5-3.0 ppm, mean 2.0 ppm. Los Angeles range 1-15 ppm, mean 6.0 ppm. - LEPS

741. Chipman, J.C., and Massey, M.T.: Proportional sampling system for the collection of an integrated auto exhaust gas sample. J. APCA 10:60-68 (Feb.) 1960.

The proportional sampling system continuously meters and accumulates a constant percentage of the exhaust gas. The electronic and analytical evaluation studies indicate that the system is reliable within the desired over-all accuracy of 90% and responds to the normal engine transient operating conditions throughout the test run. The system eliminates the need of tedious manual integration of individual operating conditions. Over-all evaluation of the exhaust gas emissions from a test run is obtained from 1 sample. Limitations are not imposed on the number of analyses that can be performed or the techniques employed. The accumulated sample can be used as a representative automotive gas source for many research experiments such as exhaust gas composition studies, reaction kinetics, plant fumigation, and eye irritation studies. - APCA 3397

742. The Clean Air Quarterly. State of California, Department of Public Health, Bureau of Air Sanitation Vol. 9, No. 1, March 1965.

This report summarizes data collected throughout the State of California for the 4th Quarter 1964. Carbon monoxide is measured continuously at 17 stations by IR methods. Highest readings were encountered in Los Angeles and Sacramento in September 1964. Levels exceeded the State's "Serious" level of 30 ppm for 8 hours. Levels in 4th quarter range from 17 ppm to 57 ppm for highest hourly concentration. Nine volumes of this exhibit have been published and are available from the State of California. - LEPS

743. Conlee, C.J., Kenline, P.A., Cummins, R.L., and Konopinski, V.J.: Motor vehicle exhaust studies at three selected sites. Arch. Environ. Health, in press.

Air quality was studied in relation to motor vehicle densities at three selected sites: The Summer Tunnel between Boston and East Boston, Massachusetts; the International Peace Bridge across the upper Niagara River between Fort Erie, Ontario, and Buffalo, New York; and Laidlaw Avenue near the Air Pollution Research Facility in Cincinnati, Ohio.

Pollutant concentrations and meteorological findings are presented for each site. Concentrations of pollutants known to be associated with auto exhaust were greater at sites of higher traffic density.

A comparison of particulate pollution levels at the Summer Tunnel operated as a one-way tube in 1963 with the tunnel carrying two-way traffic in 1961, indicates a definite decrease in pollutant levels.

Other pollutants were assumed to be dispersed in air in the same way as carbon monoxide in determining the contribution by motor vehicles to ambient air for the Summer Tunnel. Auto exhaust appears to be a prime contributor (greater than 50%) for carbon monoxide, aliphatic aldehydes, benzene-soluble particulate, and oxides of nitrogen. Lead, benzo(g, h, i)pyrene, and coronene may also be assumed to be important pollutants from auto exhaust, but they do not meet the requirements for contribution calculations. - Authors' Abst.

744. Continuous Air Monitoring Program. U.S. DHEW, PHS, Div. Air Poll., Cincinnati, Ohio, 1962, pp. 9.

The participating stations that implement the Continuous Air Monitoring Program are established and operated on a cooperative basis by Federal, State, and local agencies, The Div. of Air Poll., U.S. Public Health Service. The Program provides continuous measurements of 7 important air pollutants: carbon monoxide, sulfur dioxide, nitric oxide, nitrogen dioxide, ozone, total oxidants, and total hydrocarbons. These substances were selected from among the many which contaminate the air because they are economically and biologically significant to man and because the techniques for their analysis are advanced enough to ensure that the measurements will be valid. In addition to continuous monitoring of gases, the stations have other equipment such as particulate samplers and instruments for recording meteorological data and radioactivity levels. In the initial phase of the Program, monitoring stations are being operated in 8 cities: Chicago, Cincinnati, Detroit, Los Angeles, New Orleans, Philadelphia, San Francisco, and Washington, D. C. Some of the instruments used for recording are briefly discussed. Record-keeping and data analysis are highly automated through the use of strip chart recorders on each analyzer; a punch tape recorder to translate the curve (analog) on the strip chart into numbers (digits) that can be used in machine computation; a programmer to actuate a mechanism to punch out the digital tape in a binary decimal code; punched tapes, and their corresponding strip charts, to be sent each week to the Taft Eng. Center to be processed so that the computer can provide statistical summaries of air pollution levels, an important aid to an understanding of urban air pollution. -APCA 4763

745. Continuous Air Monitoring Program in Cincinnati, 1962-63. U.S. DHEW, PHS, Div. Air Poll., Cincinnati, Ohio, 1965.

This report which was compiled by the Air Quality Section of the Laboratory of Engineering and Physical Sciences, Robert A. Taft Sanitary Engineering Center, presents the results of the operation of the Public Health Service Continuous Air Monitoring Program (CAMP) in Cincinnati, Ohio, during 1962 and 1963. Data on atmospheric levels of sulfur dioxide, nitric oxide, nitrogen dioxide, total oxidants, total hydrocarbons, and carbon monoxide, are analyzed and discussed. The data are tabulated as hourly, daily, and monthly mean concentrations. Background information about Cincinnati and description of the instrumentation are included. -APCA 65-38

746. Davies, G.M., Jones, J.G., and Warner, C.G.: A continuously recording atmospheric carbon monoxide monitoring system with fully automatic alarms in a blast furnace area. British J. Indust. Med. 22:270-278 (Oct.) 1965.

A continuously recording carbon monoxide monitoring system with fully automatic alarms is described for use in blast furnace areas. The equipment comprised the Mines Safety Appliances Model 200 infra-red analyser, pumping system, recorder, extension meter, and alarm unit.

Use of the apparatus showed that concentrations of carbon monoxide in the blast furnace area studied were mostly in the range of 0 to 49 p.p.m. Readings of 200 p.p.m. and over generally indicated that some abnormal and potentially dangerous incident had occurred. Examples of such incidents are given.

A visual alarm was set at 200 p.p.m., a level at which work could safely continue for a limited period, and an auditory alarm at 500 p.p.m., at which level immediate action was necessary. The theoretical reasons for selecting these levels are discussed, and practical results are quoted to confirm their suitability. Authors' Abst.

747. Gruber, C.W.: APM-3 Recommended standard methods for continuing air monitoring for gaseous contaminants. TR-2, Air Pollution Measurements Committee. J. APCA 15:313 (July) 1965.

The purpose of Manual APM-3 is to provide a guide which will help increase the uniformity between various surveys, and thereby increase the useability of the data by others. Manual APM-3 will include procedures for the following gases: APM-3.2--Sulfur Dioxide; APM-3.3--Hydrogen Sulfide; APM-3.4--Oxidants and Ozone; APM-3.5--

Oxides of Nitrogen; APM-3.6--Carbon Monoxide; APM-3.7--Fluorides; APM-3.8--Hydrocarbons; APM-3.9--Aldehydes.

It is hoped by utilizing Standard Methods for Continuous Monitoring of the Atmosphere air quality data will become more meaningful as monitoring is being carried on by a multitude of governmental agencies research organizations and industry. It is hoped that by standardizing monitoring methods, the path to air quality standard setting will be made smoother. It is also hoped that by utilizing standard monitoring methods our knowledge of what's in the air will be broadened and made more useful to the researchers who are searching out the affects of air pollution upon man and materials. - Author's Sum. Modified.

748. Hocker, A.J.: Atmospheric Contaminant Variations by Day of Week Summer 1960 and Winter 1961. Los Angeles County Air Pollution Control District, January 1963.

The peak values for 8 continuous stations were ranked by concentration for the summer (July, Aug., Sept.) of 1960 and winter (Jan., Feb., March). Tuesday was highest in summer, Sunday generally lowest. Tuesday was also highest in winter, with Wednesday lowest (last 3 days very close). Morning peaks generally higher than evening. Peak summer value was 18 ppm. Winter values much higher with 12 station days above 18 ppm. (Maximum winter about 24 ppm.). - LEPS

749. Jutze, G.A., and Tabor, E.C.: The continuous air monitoring program. J. APCA 13:278-280 (June)1963.

As required by recent legislation, the Public Health Service has extended its program of investigations of the role of auto exhaust in air pollution. One phase of this program is a study, in major American cities, of the concentrations of various gaseous air pollutants that may be related to auto exhaust.

Each station is equipped with seven automatic continuous analyzers for the measurement of SO_2, NO_2, NO, CO, total oxidants, total hydrocarbons, and ozone.

It may be possible to select contaminants that would serve as general indices for several pollutants related to the same general sources, by a statistical analysis of the interrelationships between the various pollutants measured. - From Text - AGC

749a Lynn, D.A., and McMullen, T.B.: Air pollution in six major U.S. cities as measured by the Continuous Air Monitoring Program. J. APCA 16:186-190 (April) 1966.

Data obtained by the Continuous Air Monitoring Program (CAMP) in six cities during two years are summarized. Six gaseous pollutants (SO_2, NO, NO_2, Total Oxidant, Total Hydrocarbon, and CO) were monitored in Cincinnati, Chicago, New Orleans, Philadelphia, San Francisco, and

Washington, D.C. during 1962 and 1963. The data serve as a basis for describing several contrasts and similarities in the nature of air pollution experienced in six cities, which represent a broad geographical and climatological range of urban environments. Specific topics covered are: typical pollutant levels, patterns of daily and seasonal variations, and unusual phenomena such as atmospheric stagnation periods and photochemical smog formation. - Authors' Abst.

750. National Air Sampling Network. Air Quality Data, 1962. U.S. DHEW, PHS, Div. of Air Poll., Cincinnati, Ohio, August 1963, 50 pp.

This report contains summaries of air quality data for particulate and gaseous pollutants obtained from samples collected by stations of the National Air Sampling Network during 1962. Included also are data obtained by the analysis of selected particulate samples collected during the period of 1958-1961. For the first time data from State Air Sampling Networks are included in the National Air Sampling Network report, with data for this 1962 report being provided by Maryland, Massachusetts, Montana, Texas, and Washington. The extensive tables of data (pages 3-50) give information on suspended particulate matter (urban and nonurban), benzene-soluble organic matter (urban and nonurban), radioactivity, nitrates, sulfates, cadmium, chromium, copper, iron, lead, maganese, molybdenum, nickel, tin, titanium, vanadium, zinc, nitrogen dioxide, and sulfur dioxide. - APCA 62-366

751. Ryazanov, V.A., Alekseeva, M.V., and Senderikhina, D.Ya.: Methods for the collection and study of air samples in the control of a atmospheric cleanliness in inhabited localities. In: Levine, B.S. (translator) and Ryazanov, V.A. (editor): Limits of Allowable Concentrations of Atmospheric Pollutants. Book 1, 1952, pp. 89-100, CFSTI-TT-59-21173, U.S. Dept. of Commerce, Springfield, Va.

Methods of sampling and sampling devices are described. The sensitivity of the methods recommended for the determination of maximal single concentrations, for the determination of average 24 hours' concentrations using the intermittent method of sample collecting, and sensitivity of the methods recommended for use with samples of continuous 24 hours' aspiration are illustrated in three tables. This information presented indicates that the 24 hours' aspiration method is applicable to 8 ingredients only; carbon monoxide and oxides of nitrogen are best determined by the method of intermittent aspiration. Furthermore, an analysis of the data presented in the Table indicates that the aspiration rate for the ingredients listed ranges between 10 - 5000 l/hour; the total volume ranges between 240 - 12 000 liters. Thus, the tests are so arranged as to make them sufficiently sensitive for the determination of average 24 hours' concentrations, since the tests are from 2 - 8 times as sensitive as required for the determination of the limits of allowable concentrations. - Author-AGC

751a. Sakabe, H., Soda, R., Matsumura, Y., Honma, K., and Nozaki, K.: Air pollution study at heavy traffic road. Bull. Nat. Inst. Indust. Health (Japan) 4:72-76, 1960.

Carbon monoxide determinations were made by means of Kitigawa colorimetric tubes at the center of a heavy traffic Y intersection in Tokyo on March 3 and 4, 1960. Samples were collected every hour from 8 through 11 A.M., 2 P.M. and every hour from 3 to 7 P.M. on both days omitting the 11 o'clock sample on March 4. Concentrations ranged from 2.5 to 10.0 ppm on March 3 with a mean of 5.0 ppm. On March 4, the range was from 4.8 to 20.2 ppm with a mean of 12.2 ppm. - PHS-RG 5676

752. Sharrah, J.S.: The significance of instantaneous peak concentrations in air pollution. J. APCA 2:3-4 (July) 1954.

In customary measurements of air pollution, samples are taken continuously for 20 minutes or longer. An average value thus obtained is suitable for many purposes, but brief peak concentrations are missed. These peak concentrations are important from the standpoints of health, effects of irritant gases, annoyance from particulate matter, effect on vegetation, and the soiling, corrosive, and deteriorating effects of air pollution. Examples are given of peak concentrations of sulfur dioxide, hydrogen sulfide, and carbon monoxide, which were not detected by continuous sampling, but were plainly shown by short-time sampling, and were noticeable by odor or otherwise and were the occasion for complaints. Concentrations of five ppm. of sulfur dioxide, 175 ppm. of hydrogen sulfide, and 450 ppm. of carbon monoxide for short periods were thus detected. An example of the effect of peak concentrations is the darkening of paint by hydrogen sulfide. - APCA 373

753. Stern, A.C.: Data gathering and monitoring equipment in air pollution control programs. Amer. J. Public Health 53:1972-1981 (Dec.) 1963.

This paper is limited in its coverage to the kind of data gathered in greatest quantity by monitoring equipment in air pollution programs, namely, pollutant concentrations. The body of gas monitored for pollutant concentrations may variously be a gas stream being discharged to the ambient air; a synthetic atmosphere used for research purposes; or the ambient air--the principal distinction among them being the range of concentrations measured. Generally, high concentrations are monitored in effluent gas streams; moderate concentrations in synthetic research atmospheres; and low concentrations in the ambient air. This distinction is, in turn, reflected in the sensitivity required of instruments for these several applications. The most common method of monitoring an effluent gas stream by continuous instrumental means is to measure its opacity to the transmission of a beam of light. Closed-circuit television monitoring of the effluent gas stream is now available for plant operation control. Large particles are not monitored by light transmission across the gas stream carrying them. Recently a continuous instrumental monitor for these particles has been introduced in Germany and another in England. There is as yet no substantial American experience with either of these monitors. In studying synthetic atmospheres the type of monitoring equipment and data gathering required varies mainly with project duration. In 1 long-time study of exposure of citrus trees, by the University of California (Riverside) research group, to atmospheres from which certain pollutants have been removed, the monitoring data are digitalized and recorded in form for automatic computation. In studies of ambient air the methods developed for handling data are cited in the project by the Los Angeles County APCD and by the Continuous Air Monitoring Program of the USPHS. The future is likely to see more telemetering of air quality data by both wire and radio linkage. And in the Continuous Air Monitoring Program there will probably be a more direct linkage between the sensing instrument and the computer. Also for pollutants which are at less than detectable level for a greater percentage of the time, instruments will probably be build to rapidly respond to, and submit, significant levels but to curtail the transmission of insignificant data. There is a need for monitoring systems for air quality for rural areas with which urban concentrations may be compared. Also there is a need to develop instruments to monitor the ambient air for pollutants we do not now know how to monitor. - APCA 6093

SOURCES

Aircraft Cabins, Submarines and Others

754. Alvis, H.J., and Tanner, C.W.: Carbon monoxide toxicity in submarine operations. Arch. Indust. Hyg. & Occupat. Med. 6:404-406 (Nov.) 1952.

A case of mass carbon monoxide poisoning in a submarine is reported. Men engaged in active work were the first to be affected. First symptoms noted were headaches, and as condition progressed nausea, vomiting and headaches so severe that sedation was required. CO concentration was found to be 0.01% with CO_2 level at 2% at about the same time. Exposure lasted approximately 10 hours. The condition was diagnosed and proper treatment instituted when it became apparent that the entire ship's crew was involved. Authors assume that in comparing the symptoms reported with the table in McFarland's work: Human Factors in Air Transport Design, N.Y. McGraw-Hill, 1946, Chap. 6, that all aboard (with one exception) had probably a carboxyhemoglobin saturation between 10 and 20%, several 20 to 30% saturation, and a few may have had as high a saturation as 30 to 40%. - AGC

755. Aviation Toxicology. An Introduction to the Subject and a Handbook of Data. The Blakiston Co., New York, Toronto, 1953, pp. 120.

This handbook on aviation toxicology provides toxicity data on chemicals of special interest in aviation.
CO is the only toxic gas for which allowable concentration limits have been generally prescribed in aviation. The allowable limit of concentration for CO set by military and civilian agencies of different countries vary somewhat. The average limit is one part in 20,000 parts of air (14 b) for civil airplanes in the U.S. In moderate altitudes carbon monoxide does not have any ill effects. Author points out, however, that careful laboratory tests have shown that vision is somewhat impaired at, or even below, this concentration. The concentration of carboxyhemoglobin in the blood stream at high altitude, and the general properties and occurrence of CO are discussed in this book. There are diagrams showing time-concentration curves of CO toxicity. - AGC

755a. Beard, R.R., and Pribram, K.: Effects of toxic agents and environmental factors on human behavior. Department of Defense, Armed Forces Epidem. Board, Washington, D.C., Feb. 1964, DDC No. 438409.

Dynamic exposure chambers have been constructed in which an air flow of up to 100 liters per minute can be maintained. Carbon monoxide has been metered to the chambers under continuous monitoring, to expose rats to concentrations from 100 to 1,000 p.p.m. Rats were trained to various operant behavior schedules. Conditioned behavior during 10 minutes of each hour for long periods gave unstable response patterns. Continuous observation for periods of 1-1/2 hours showed rapid reduction of response rate and disturbance of the "grain" of behavior with CO concentrations of 500 p.p.m. and higher; at 250 p.p.m. perceptible disturbance of response pattern became apparent within an hour. A response-attenuation ratio taking into account the normal behavior of an animal on the day of exposure to CO as well as preceding control periods was devised. Equipment for trials of the effect of CO on discrimination capacities in humans has been developed. Methods for detailed analysis of behavior patterns by computer techniques are being perfected. - Authors' Abst.

755b. Birren, J.E., Fisher, M.B., Vollmer, E.P., and King, B.G.: Effects of anoxia on performance at several simulated altitudes. J. Exp. Psycholog. 36:35-49 (Feb.) 1964.

This paper reports the results of a series of tests on human Ss exposed to simulated altitudes in a low pressure chamber. These tests were made not to determine possible bases for personnel selection but to provide limited performance norms for subsequent studies of variables superimposed on anoxia, e.g., carbon monoxide. The purpose of the present investigation is similar to that of many other studies employing sensorimotor tests, that is, to appraise the efficiency of personnel under an environmental stress.

756. Gerard, P.: Engineer Design Test of Howitzer, Light, Self Propelled, 105-MM, XM 104. Aberdeen Proving Ground, Md, May 1963, DDC-AD 405791.

The engine exhaust is discharged directly into the vehicle during amphibious operations. Although the vehicle is completely open, operating personnel may still inhale relatively large amounts of carbon monoxide. A "CO" concentration in excess of 0.1% was recorded at the right rear personnel seat. It was necessary to install extra piping to direct the exhaust gases out of the inclosure during these tests. Consideration should be given to modifying the present exhaust configuration for deep water fording. A CO level of 0.01% is accepted; however, any degree of contamination, no matter how slight, has adverse affects on military personnel operating efficiency. - Author's Abst.

757. Gilinskiy, V.A., Chapek, A.V., Kozlova, A.G., Kulikova, N.M., and A. Ya. Loshak: The effect of low concentrations of carbon monoxide on man in pressurized cabins of passenger planes. In: Parin, V.V. (editor) Aviation and Space Medicine, Moscow, 1963. NASA Technical Translation TT-F-228.

Pressure-chamber experiments were performed on 82 persons to study the effect of low concentrations of carbon monoxide. Also, 30 flights on IL-18, AN-10, and TU-104 planes were made during which 185 members of the crew and passengers were examined and 347 air samples were obtained in the cabins. The results of the investigations showed that 3 hours' exposure to carbon monoxide (starting with 0.01 mg/liter or more), both under experimental conditions (ground and pressure-chamber at 2400 m) and during actual flight had adverse effects on the functioning of several organs and systems, namely: (a) Higher nervous activity; (b) Functions of the visual and vestibular analyzers; (c) Metabolic processes; (d) Cardiovascular system; (e) Muscular strength, (f) Tissue respiration and; (g) Leukopoiesis. On the basis of the physiological-sanitary data obtained and the results of laboratory tests, it is suggested that the maximum permissible concentration of carbon monoxide in pressurized passenger airplane cabins be 0.01 mg/liter. - Authors' Abst.

758. Heim, J.W.: The toxicity of carbon monoxide at high altitudes. J. Aviation Med. 10:211-215 (Dec.) 1939.

Author states that accurate quantitative data on the behavior of carbon monoxide at reduced atmospheric pressures and on permissible concentrations in aircraft compartments at heights is hardly available in the literature. There is also a scarity of information on the tolerance of CO at high altitudes. The purpose of this study is investigation of the toxicity of CO at reduced barometric pressure. Theoretical calculations based on physico-chemical laws governing the combination of $CO + O_2$ with hemoglobin are expressed algebraically by equations. Author concludes that concentrations of CO which are innocous at prescribed levels are dangerous at even moderate altitudes and it is most imperative that no trace of this gas should be permitted to exist in airplane compartments. - AGC

759. Lamon, H.J.: Report on Carbon Monoxide Contamination Caused by the Weapon System of the M60 Tank. First Report on OTAC Project No. IT-5172, Aberdeen Proving Ground, Md., March 1960, 20 pp. DDC AD 234022.

The weapons of the M60 tank were fired independently and in an all-weapons condition to determine the resulting carbon monoxide concentrations. The basic tank condition was hatches closed, turret ventilator off, and tank engine off. For those firings which produced hazardous concentrations further tank conditions were investigated. These conditions were hatches closed, turret ventilator operating, and tank engine induction air from either the engine compartment or crew compartment. Unsafe conditions exist in the tank for certain firing conditions when the turret ventilator is not used. All weapon combinations could be made safe by using the turret ventilator. It is recommended that, when firing the weapon system, the tank be judged safe for occupancy only when the turret ventilator is used. - Author's Abst.

760. Lentz, E.C.: Human factors in "cause undetermined" accidents. Aerospace Med. 36:214-222 (March) 1965.

USAF aircraft accidents over a four-year period that remain categorized as cause undetermined indicate that the man-machine complex tends to fail during the stressful phases of flight. Loss of control and high speed impact are factors common to many of this series. Man's limitations and specifically his ability to maintain orientation - i.e., disorientation - are major problems in the operation of high performance aircraft. Aircraft performance has advanced to the place where exploration of the operational perimeters of the craft is reserved for the test pilot. Experienced combat pilots may still be novices with respect to the vagarities of the aircraft he flies. Safety of flight is enhanced by the division of duties with a qualified co-pilot.

Loss of control due to impaired consciousness attributable to carbon monoxide from refueling operations has been raised as a possibility. There are two instances in this series of loss of control associated with refueling operations. Turbine engines are efficient oxidizers of fuel. This combined with distances and dilution seriously compromises the hypothesis that the cockpit of a plane could accumulate disabling amounts of carbon monoxide from air refueling operations. - Author's Abst. Modified

761. Nichols, G., Jr., and Kinsey, J.L.: Carbon monoxide as a habitability factor in prolonged submarine submergence. U.S. Naval Medical Research Laboratory, New London, Conn., Report No. 223 (April 16) 1953.

Toxic conc. of CO accumulate when there is unrestricted smoking in sealed spaces, such as a submarine during a prolonged submergence. 23 volunteers on Operation Hideout were exposed to CO levels of approx. 100 or more ppm for continuous period of 6 days, following a period of 12 days' exposure to CO conc. between 50 and 100 ppm and period of unknown length during which this conc. accumulated; 6 day period was followed by 4 days of exposure to CO conc. varying from 25 to 100 ppm. Comparing 6 day period of exposure to 100 ppm with 6 day period immediately following return to outboard ventilation, subjective complaints as ms. by number of headaches were significant at 10% level. Significant amts. of hb were saturated with CO; in only 2 cases, however, was this considered to be in range where subjective complaints occur, and in each of these 2 there were no symptoms. CO-blood saturation dropped rapidly (1 day) upon return to outboard ventilation. - Kett.

762. Schulte, J.H.: The medical aspects of closed cabin atmosphere control. Military Med. 126:40-48 (Jan.) 1961.

One hundred and eight healthy adult males between the ages of 17 and 37 years were exposed in an operating nuclear submarine, to an atmosphere with an average consistency of 19.7% oxygen, 1.04% carbon dioxide, 1% hydrogen, 44 ppm carbon monoxide, 15 ppm freon-12 and approximately 78% nitrogen continuously for 72 days. The atmosphere occasionally contained small amounts of ammonia, chlorine and aromatic hydrocarbons. Presumably other contaminants were also present in trace amounts.

The physiological and metabolic evaluations which were studied during the 72 days exposure consisted of the general health, vital signs, blood cell determinations, exercise tolerance, caloric requirements, and dietary habits. Using these criteria, no changes occurred which are attributable to exposure to the existing atmosphere and no harmful effects were elicited either during or shortly following the exposure. - Author's Sum.

763. Schulte, J.H.: Sealed environment in relation to health and disease. Arch. Environ. Health 8:438-452 (March) 1964.

The general health aspects of life in a sealed environment are related primarily to habitability and atmospheric control. The control of the atmosphere involves: (a) some means to provide the continual addition of oxygen in sufficient quantity to support life and preserve health, and (b) methods to effect the continuous removal of carbon dioxide, carbon monoxide, and other atmospheric contaminants to prevent them from gradually increasing to concentrations which could produce illness. The habitability of a sealed environment is maintained within a comfortable and healthful range by the addition or removal of heat and water vapor.

Most of the experience gained in the problems related to health and disease during prolonged existence in a sealed environment has been obtained from the operations of nuclear-powered submarines. These submarine cruises have demonstrated the number, type, and amount of atmospheric contaminants which are produced by man and his equipment within the sealed environment.

The progress that has been made in analyzing the atmospheric content of a sealed environment has been reiterated. A number of the atmospheric constituents have been discussed in greater detail in regard to their source, effects upon health, and methods of control. The need for control of temperature and humidity and for protection from radiation has also been included in the discussion. These needs and methods for controlling the atmospheric constituents, temperature, humidity, and radiation exposure in a sealed environment have been projected to the future space vehicle. - Author's Sum.

764. Slusher, G.R.: Analysis of Engine Exhaust System Failures in General Aviation Aircraft. Technical Report FAA-ADS-29, Federal Aviation Agency, Sept. 1964, 18 pp.

A study and an analysis were made of the records on engine exhaust system malfunctions in the single engine type general aviation aircraft from the time period of 1958 through 1962 to determine the extent of the inflight hazards involving carbon monoxide poisoning, fire, power loss, etc.

The results disclosed approximately 50 percent of the exhaust system failures occurred in the exhaust gas-to-air heat exchanger, 20 percent in the stacks or manifolds, and 20 percent internal to the muffler (baffles and diffusers).

Nineteen illnesses and twelve fatalities out of 38 reported incidents of exhaust gases in the cabin were documented. Fourteen fires and 70 incidents of partial engine power loss or complete power failure were also reported. Analysis disclosed that the exhaust systems of newer aircraft fail at a markedly higher rate than the exhaust systems of older aircraft. - Author's Abst.

765. Smith, P.K.: Carboxyhemoglobin Concentrations in Personnel After Flying P-40-N Aircraft. School of Aviation Medicare, Randolph AFB, Texas, May 5, 1945, 3 pp. DDC AD 121708.

Measurements were made of the carboxyhemoglobin concentrations in eighteen pilots after flying fourteen different P-40-N aircraft. The concentrations of carboxyhemoglobin varied from zero to eight per cent of the total hemoglobin. It is concluded that the concentrations of carboxyhemoglobin found were probably not high enough to interfere with flying efficiency. - Author's Abst.

766. Speert, H.: Noxious vapors in aircraft cabins. Occupat. Med. 2:101-115 (Aug.) 1946.

Author describes specific cause factors responsible for impairment of efficiency of flying personnel and the relationship between such impairment and accident causation case histories of aircraft accidents in which the presence of noxious gases or vapors played a part are presented. CO is. from a toxicological point of view, the most important constituent of the exhaust mixture. The maximum allowable concentration of CO in Army Air Force aircraft cabins is 0.005%. All new aircraft models must meet this specification. Some aircrafts with exhaust heaters are equipped with a signal assembly which activates a red light on the pilot's instrument panel when the concentration of CO in the atmosphere reaches 0.005 per cent. CO content of the blood of pilots before and after flights is being measured to obtain a control value. It is of importance to obtain control value before flight, especially for smokers, in whom the blood CO level may normally be as high as seven to eight per cent of saturation. CO is a tissue asphyxant producing anoxia, effecting the most sensitive central nervous system first. Acute severe exposure results in rapid onset of unconsciousness; in less severe cases, great individual variation in symptoms is encountered. Even small amounts of CO in the blood cause significant visual impairment of special importance to aviators. For example a blood saturation of only 10% CO at an altitude of 6,000 feet can cause deterioration of visual discrimination to a level corresponding to an altitude of 12,500 feet. Hazards of exposure to CO increases with altitude. Minimal degrees of anoxia resulting from altitude, combined with the slight anoxia produced by only small amounts of circulating CO, each alone harmless, may together produce moderately severe symptoms of anoxia. These relationships have been established by theory and experiment. - AGC

767. Stembridge, V.A., and Goldbaum, L.R.: The role of the Armed Forces Institute of Pathology in tissue toxicity study. Aviation Med. Symposium, Nov. 1957, pp. 5-8.

During the period from May 1957 through Oct. 1957, 269 determinations for CO have been accomplished at the Armed Forces Institute of Pathology utilizing a new method for obtaining a specimen. Of those 110 determinations for carbon monoxide on post-mortem tissues, 11 (10%) showed an elevation above 10 percent saturation. None of these 11 cases were considered a sudden death and in all there was evidence that the individual died primarily due to fire.

Post-mortem CO determinations are done in aircraft accident victims for two basic reasons: First, to determine whether carbon monoxide was present in the cockpit environment prior to impact (due to such factors as in-flight fires, exhaust fumes or improper venting of other combustion products) and second, to determine whether or not an individual was alive following an impact associated with fire. - From Text-AGC

767a. Vollmer, E.P., King, B.G., Fisher, M.B., and Birren, J.E.: The Effects of Carbon Monoxide on Three Types of Performance, at Simulated Altitudes of 10,000 and 15,500 Feet. NMRI Res. Project X-417, Report No. 7, Feb. 27, 1945, and J. Exp. Psychol. 36:244-251, 1946.

Measurements of the critical flicker frequency threshold, body sway, and the red visual field were made on subjects before, during and after low pressure chamber runs. Twenty subjects with 12 to 22 per cent blood carboxyhemoglobin (COHb) took part in runs at 15,500 feet, and six subjects with 5 to 10 per cent COHb were tested at 10,000 feet. Control runs were made at the same altitudes with the same subjects.

There was a significant impairment of performance at altitude, both under conditions of anoxia alone and anoxia after exposure to carbon monoxide (CO) as compared with performance at sea level.

There was no statistically significant difference between the mean scores of the tests during anoxia alone and during anoxia following administration of CO. Furthermore, the time-performance curves for group means during the hour at altitude are nearly coincident under the two conditions.

All the mean values for performance of each of the three tests at altitude are within one standard deviation of the sea level mean. (More than one-half of the scores for individual performance in the two series may therefore be expected to fall within the range of performance of normal subjects at sea level.)

Individual responses were variable and without correlation with the percentage of increment or of total COHb in the blood.

Three of the subjects who started the experiments showed symptoms of impending collapse at 15,500 feet without CO. One of these had successfully completed his corresponding CO run; the other two did not participate in CO runs.

Five subjects showed symptoms of impending collapse at altitude (one at 10,000, four at 15,500 feet) after they had breathed mixtures containing CO. - Authors' Sum.

768. White, J.J.: Carbon monoxide and its relation to aircraft. U.S. Naval Med. Bull. 30:151-165 (April) 1932.

Carbon monoxide, a product of incomplete combustion, is present in the exhaust gas of all types of airplanes. In some types of planes, depending on type of exhaust leads, fuselage, etc., this gas is carried back to the cockpits of the plane in sufficient concentration to result in as much as 15 per cent saturation of the blood of the pilot and other occupants of the plane.

Although the highest saturation of blood obtained during the investigation (15 per cent) is not sufficient to render a person unconscious, or to be a direct cause of a crash, it is known that the absorption of even minute amounts of carbon monoxide is highly undesirable, due to the probable adverse effect on the efficiency of the pilot.

The fact that exposure to a low concentration over a long period is more harmful than a brief exposure to a very high concentration, increases the importance of eliminating all traces of carbon monoxide.

Comparatively simple and inexpensive modification of the exhaust leads has eliminated carbon monoxide from the area where it is absorbed by the pilot or other occupants of the plane. - Author's Sum.

769. Wilks, S.S.: Preliminary Studies on Light-Induced Carbon Monoxide in Closed Environments. USAF School of Aviation Med., Brooks AF Base, Tex., Sept. 1963, CFSTI AD-420946.

This paper presents experimental data concerning the effects of solar light upon certain classes of organic substances which may be components of the sealed environment of space vehicles. Many materials such as organic plastics, pigments, insulating material, etc., will, when exposed to light in the presence of oxygen, liberate a number of toxic end products such as carbon monoxide, aldehydes, acids, and certain hydrocarbons. In a sealed environment these agents may, unless removed, reach levels toxic to human beings during a long sojourn in a sealed system. Therefore, along with products that may result from thermal and electrical activity (motors, generators, etc.) these products may constitute a considerable hazard in sealed environments. - Author's Abst.

770. Wilks, S.S.: Toxic photooxidation products in closed environments. Aerospace Med. 34:838-841 (Sept.) 1963.

The evidence of carbon monoxide production from the action of light and oxygen on many classes of organic substances and compounds indicates the necessity for adequate protection of susceptible materials from the ravages of the combination of light and oxygen in small, sealed environments designed for human occupancy. Materials to be used in spacecraft should be thoroughly tested for their stability to effects of radiation. Materials within the vehicle should, as far as possible, be shielded from certain components of the spectrum. Appropriate methods for CO elimination should be a permanent installation. - Author's Conclusion

Diesel Engines

771. Ash, S.H., and Naus, L.L.: Use of diesel engines in tunnels. Bureau of Mines Info. Cir. No. 7222, 1942, 26 pp.

In diesel-engine operations when the exhaust gases contain carbon monoxide in the amount of 0.01 percent and carbon dioxide to 0.3 percent, visibility in a tunnel in which the diesel is used is poor and the aldehydes and other irritants are obnoxious after a relatively short exposure. In general, the irritants, such as aldehydes, odors, and smoke follow the trend of the toxic gases, but under improper maintenance they are conspicuously present at all stages of operation. Proper mechanical condition at all times is necessary for a diesel engine to insure against its exhaust containing dangerous concentrations of noxious gases.

The investigation shows the value of field study of diesel locomotives in actual operation, and it was observations so obtained that indicated the amount of carbon monoxide in the exhaust gas as a yardstick for the control of atmospheric conditions. The control of noxious gases in the general air when diesel locomotives are being used should be based upon a carbon monoxide control value of 10 to 20 p. p. m. - BMB 495

772. Berger, L.B., Elliott, M.A., Holtz, J.C., and Schrenk, H.H.: Diesel Engines Underground. U.S. Bureau of Mines Rept. Investigations No. 3508, 1940, 48 pp.; No. 3541, 1940, 18 pp.

These reports and the investigations upon which they are based are in regard to the factors that must be considered if diesel engines are to be used safely underground. Two four-stroke-cycle diesel engines, one of maximum rated speed of 1,400 r. p. m. and 44 b. h. p. and the other of 2,600 r. p. m. and 7 b. h. p., were used in the experiments. Both were in good mechanical condition and each was mounted on a power unit. Exhaust-gas samples were taken and required analyses run to determine the factors of interest to the investigators.

Exhaust-gas analysis was made for carbon dioxide, carbon monoxide, oxygen, hydrogen, and methane; these data then were correlated with fuel-air ratio. It was shown that the concentration of these constituents is governed by the fuel-air ratio and varies as does the relation of fuel to intake air. - BMB 483

773. Bus fumes acquitted: New York Transit Commission finds no dangerous concentration of carbon monoxide. Transit J. 80:441, 1936.

Although the belief is widespread that dangerous concentrations of carbon monoxide are often present in buses and on the streets where they operate. this idea is erroneous, according to the findings of the engineering department of the New York Transit Commission. In all the time buses have been running, no case fatality has been reported as due to carbon monoxide. The offensive aldehydes give rise to complaints of bus fumes. The highest concentration of carbon monoxide found on a bus was 2 parts per 10,000 and this was found while the bus was standing. - BMB 643

Cartigny, S., and Degueldre, G.: Cleaning of exhaust from diesel engines. Institut d'Hygiene des Mines. Hasselt. Bulletin des Documentation techn. No. 33, July 21, 1957.

The method employed for the cleaning of exhaust gases from diesel engines used to operate tractors during the day, and the Oxicat-Houdry installation used for this purpose are described in this paper. A generation of 28 PS was attached to the tractor which, by employing resistance altered the load of the diesel engine. The conditions (humidity content, temperature) of the volume of air drawn in by the engine and the conditions and composition of the exhaust, particularly its CO, CO_2, and O_2 contents were investigated. - AGC

Elliott, M.A., Nebel, G.J., and Rounds, F.G.: The composition of exhaust gases from diesel, gasoline, and propane-powered motor coaches. J. APCA 5:103-108 (Aug.) 1955.

Exhaust-gas samples were obtained from diesel, gasoline and propane-powered motor coaches of similar passenger capacity under idling,accelerating, cruising, and decelerating conditions. The samples were analyzed for carbon monoxide, oxides of nitrogen, formaldehyde, and hydrocarbons. In addition the exhaust gas flow rates were measured to permit calculation of the emission rate for each constituent at each driving condition. Based on a typical city driving pattern, it was concluded: (1) carbon monoxide emission from the diesel coaches was only a small fraction of that from the gasoline and propane coaches, and (2) the differences observed in the emission of oxides of nitrogen, formaldehyde, and hydrocarbons by the three coach types were relatively small. No one coach type discharged either the greatest or least amounts of all of these three constituents. - APCA 475

The exhaust from a new hybrid diesel/gasoline engine. Chem. Week, Dec. 20, 1965, p. 29.

An injector system rather than a carburetor injects fuel to the combustion chamber in this new type of engine, which was developed by the Maschinenfabrik Augsburg-Nuernberg, A.G. (MAN), Munich, West Germany. Low carbon monoxide content at idle, namely 0.12% compared to 10 to 12% for conventional gasoline engines, is a primary advantage of this new design. Other advantages are low fuel consumption and multifuel capability. A number of firms in West Germany are at present testing this new engine designed primarily for military vehicles. Although it can be used in automobiles, it may be too costly at present for acceptance by auto makers. - AGC

777. Holtz, J.C., and Elliott, M.A.: The significance of diesel exhaust-gas analysis. Trans. Amer. Soc. Mech. Eng. 63: 97-105, 1941.

The significance of data on the combustion processes in the diesel engine is discussed. Two diesel engines in good mechanical condition were tested; exhaust-gas samples were taken and analyzed for oxygen, carbon monoxide. hydrogen, methane, nitrogen, aldehydes, and oxides of nitrogen.

Among the topics discussed are: The relation of exhaust-gas composition to fuel-air ratio; the relation of exhaust-gas composition to combustion performance; the products of incomplete combustion and the significance of these factors in the light of safe diesel operation.

The products of incomplete combustion in diesel engines are carbon monoxide, aldehydes, free carbon, hydrogen, and methane. Two processes of combustion occur simultaneously. These are direct oxidation and destructive combustion. If the reactions in the direct-oxidation process are chilled before oxidation is complete, carbon monoxide, aldehydes, and organic acids will be present in the exhaust gases. Increase in concentration of CO and aldehydes at low fuel-air ratios indicates that chilling is more pronounced at these ratios. - BMB 491

778. Maurin, Gen., and Kling, A.: The pollution of air by diesel engines. Rev. petrol., No. 768, pp. 49-55, 1938.

CO content in diesel exhaust gases is very low. The amount of smoke and its odor are less at full load than under part load. Unburned solids and liquids, in the form of lubricating oil, organic acids, aldehydes, and oxides of sulfur, are always present in the exhaust. Purification by means of a water bath and cyclone-type separator in series can eliminate 79 percent of the solids and liquids, the other 21 percent being removed with an activated carbon filter. Addition of Na_2CO_3 or $Ca(OH)_2$ to the water bath is recommended. - BMB 647

779. Report on diesel smoke. Information Report No. 2. (Vehicular Exhaust Committee, Chairman: Jensen, D.A.) J. APCA 13:290-291 (June) 1963.

The purpose of this report is to present a summary of factors that influence the production of exhaust smoke in diesel engines. Also provided is information relating to known methods for reducing or eliminating diesel smoke. It is, in effect, a report on the current state of the art in the area of diesel smoke and is intended to be used as a supplement to the results of the laboratory research being carried on to determine the chemical composition of diesel engine exhaust.

Included in this report are discussions of diesel fuel properties, engine adjustment and maintenance procedures, engine operation and

driver procedures, and features of engine devices. All of these items have an important bearing on the smoke properties of diesel engines installed in motor vehicles. - Author's Introduction

780. Schrenk, H.H., and Berger, L.B.: Composition of diesel engine exhaust gas. Amer. J. Pub. Health 31:669-681, 1941.

Exhaust-gas composition from two diesel engines in good mechanical condition was determined at various speeds and power output. The exhaust-gas constituents were CO, N oxides, CO_2, aldehydes, soot, O_2, N_2, H_2O vapors, and in some instances H and CH_4 or other hydrocarbons. Carbon monoxide, carbon dioxide, and oxides of nitrogen were found in quantities harmful to breathe, and, in many instances, very objectionable amounts of aldehydes and smoke were produced.

The production of carbon monoxide and smoke, as well as aldehydes, can be largely controlled by the proper adjustment of fuel-air ratio without a significant loss of power output. - BMB 494

Garages and Workshops

781. Audere, A.K. Carbon monoxide air pollution in shops testing machine and tractor motors. Gigiena i Sanitaria 24:79-80, 1959. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 5, 1961, pp. 43-45, CFSTI-TT-61-11149, U.S. Dept. of Commerce, Springfield, Va.

Nine shops of machine and tractor stations were inspected during the years 1956 and 1957. Result of the analysis of air samples taken during testing of different kind of engines showed a relatively high concentration of carbon monoxide. It was recommended that forced draft ventilation are to be installed in the premises, to reduce the carbon monoxide concentration to the limit of tolerance. - AGC.

782. Austen, F.K.: The medical grand rounds. Massachusetts General Hospital. Amer. Pract. 13:171-185, 1962.

Among the cases discussed is one concerning a medical problem caused by CO, in connection with the construction of a garage under the Boston Common. The physiological and chemical reactions of oxygen and CO as they become bound to hemoglobin are described. The rules of how CO and hemoglobin combine are summarized in a simple equation. The severity of the symptoms of anoxia from CO poisoning as compared with anemia are explained. - AGC

783. **Barrett, H.M.: Carbon monoxide poisoning. Canadian J. Pub. Health 25:430-438, 1934.**

Carbon monoxide accounts for more human deaths annually than all other gaseous poisons combined. Its occurrence is almost universal, resulting as it does from incomplete combustion. Industrially carbon monoxide occurs in high concentration in smelters, being a major hazard in steel plants. It is to be guarded against in mines after an explosion or blasting operations. In the home it is the responsible factor in coal gas poisonings due to faulty heating appliances. The automobile produces the gas in large quantities and it is present in varying quantities in public garages. A car with the motor idling in a closed single garage produces sufficient of the gas to render the air dangerous in from five to ten minutes. It is one of the most insidious poisons known as it is odourless (except in the nearly pure form when it possesses a faint garlic odour) and produces no irritating symptoms. For these reasons a knowledge of its mode of action and methods of determining its presence are of paramount importance. - Author's Introduction

784. Berger, L.B., Elliott, M.A., Holtz, J.C., and Schrenk, H.H.: Diesel Engines Underground. U.S. Bureau of Mines Rept. Investigations No. 3508, 1940, 48 pp.; No. 3541, 1940, 18 pp.

These reports and the investigations upon which they are based are in regard to the factors that must be considered if diesel engines are to be used safely underground. Two four-stroke-cycle diesel engines, one of maximum rated speed of 14000 r. p. m. and 44 b.g.p. and the other of 2,600 r.p. m. and 7 b.h. p., were used in the experiments. Both were in good mechanical condition and each was mounted on a power unit. Exhaust-gas samples were taken and required analyses run to determine the factors of interest to the investigators.
Exhaust-gas analysis was made for carbon dioxide, carbon monoxide, oxygen, hydrogen, and methane; these data then were correlated with fuel-air ratio. It was shown that the concentration of these constituents is governed by the fuel-air ratio and varies as does the relation of fuel to intake air. - BMB 483

785. Bloomfield, B.D.: Lift trucks raise carbon monoxide level. Arch. Indust. Health (Occupat. Health News Sect.) 15:172-173 (Feb.) 1957.

A serious carbon monoxide health hazard was caused by misapplication of propane gas-powered lift trucks at a new cold storage plant. The new lift trucks were properly serviced and were believed to be in first-class operating condition. In a large storage room maintained at -10°F, two employees were slightly affected and the operator lost consciousness for about 45 minutes. The freezer room air was found to contain 400 ppm carbon monoxide but the actual exposure may have been higher. An electric lift truck was substituted for the gas-powered truck. - Author's Abst.

786. Brumbaugh, I.V., and Jones, G.W.: Carbon monoxide in the products of combustion from natural gas burners. Technologic Papers of the Bureau of Standards 16:431-450, 1921-1922.

Many natural-gas appliances are notoriously inefficient. Solid top stoves with low set burners and grid top stoves with low set burners consume two to eight times as much gas as stoves with raised burners and grid tops. On account of the liberation of carbon monoxide, a poisonous gas, with the products of combustion when the flame is improperly aerated it is not practical to place burners at the distance from ustensils where the maximum effeciency is obtained. Burners of the "star" type should be placed about 1 inch, the "slot" burner about 3/4 inch, and the "disc" type about 1-1/4 inches from utensil.

From the many tests for carbon monoxide made with five different burners and different types of flames at rates of consumption of 6.0 and 8.0 cubic feet per hour (6480 and 8640 Btu per hour), the maximum rate of liberation of carbon monoxide was found to be 0.25 cubic foot per hour and was obtained with a very soft flame and a close position of utensil which caused the flame to "float" and extend up the side of utensil. It is not a dangerous rate unless one works directly over the burner, or several burners are in use at the same time for several hours, or the room is unventilated.

No carbon monoxide was found where the blue inner cone of the flame was not allowed to touch the utensil. A yellow flame will produce carbon monoxide at a rate much greater than a blue flame when the utensil is so close to the burner as to cause a floating flame.

A natural gas flame was found to be smothered from deficiency of oxygen when the content of the atmosphere had been diminished to about 15.5 per cent. When one considers the natural ventilation which takes place through the windows and doors it would seem that the danger from carbon monoxide poisoning with natural gas top burners is quite remote. - Authors' Abst.

787. Burrell, G. A., and Gauger, A. W.: Vitiation of garage air by automobile exhaust gases. USBMTP 216, 1919, 12pp.

Experiments were made in a garage with an automobile whose engine was run at various speeds. Only information regarding poisoning due to carbon monoxide is given. Eye smarting and eye watering and illness were experienced. Although aldehydes are not mentioned, it is quite probable that these were responsible for at least a part of the effects. -BMB 393

788. Commins, B.T., Waller, R.E., and Lawther, P.J.: Air pollution in diesel bus garages. British J. Indust. Med. 14:232-239 (Oct.) 1957.

Air pollution in 2 London Transport diesel bus garages has been studied. Results of determinations of smoke, polycyclic hydrocarbons, nitrogen dioxide, aldehydes, carbon monoxide, and sulfur dioxide are given. These results are compared with analyses of the outside air. Despite large differences in the concentrations of smoke inside and outside each garage only small differences in the amounts of 3:4-benzpyrene were noted. Concentrations of nitrogen dioxide and aldehydes did not approach the threshold limit values for 8-hour shift exposures adopted by the American Conference of Governmental Industrial Hygienists in 1956. The carbon monoxide concentrations were negligible; there was no evidence of abnormal concentrations of sulfur dioxide. The significance of these findings is discussed. Work on the problem of air pollution by motor vehicles is continuing. - APCA 1548

789. Environmental Instrument Package for a Civil Defense Shelter. Thomas A. Edison Research Laboratory, West Orange, N. J., May 1964, 182 pp. DDC AD 440418.

A study of instrumentation for monitoring the environment within a civil defense survival shelter was made. The study plan traced hazardous conditions from the origin of the offending gases and vapors through man's physiological tolerance and effect to the required degree of detection instrumentation. Listed are the contaminants and conditions which might be expected, the allowable maximum concentrations for a typical shelter period, and design ranges for suitable instruments. Detection methods available in commercial instrumentation are reviewed and analyzed within the framework of shelter requirements. Representative sample devices employing the most promising techniques were obtained for test. An overall evaluation based on accuracy, reliability, ease of operation, cost, adequacy of instruction material, and general suitability for shelter use is tabulated. A list of manufacturers arranged by product, allows nonrestrictive selection of a source for any or all instrumentation requirements. Individual specifications are drawn for each of three sizes of shelter packages. Recommendations for new instruments and improvements to available devices are made. - Authors' Abst.

790. Gilbert, G.J., and Glaser, G.H.: Neurologic manifestations of chronic carbon monoxide poisoning. New England J. Med. 261:1217 1220 (Dec. 10) 1959.

A detailed case history is given of a patient suffering from chronic carbon monoxide poisoning. The condition was verified by the finding of a significantly-elevated blood carbon monoxide level. A detailed occupational history was obtained indicating that the patient had been a policeman for 18 years. His first few "spells" had occurred four years before hospital admission in 1958 at the age of 50 while he was assigned to directing heavy automobile traffic. Fearing that his job was too strenuous, he had requested transfer to the police garage and had served as a mechanic there for the past three years. It was often necessary to run the motors of the police cars in the garage, particularly in the repair of police radios which required a running motor for their operation. The garage doors were usually left open but were closed often after March to keep out the sun. The time of closing of the garage doors corresponded to the period of exacerbation of the patient's symptomatology. The patient had anorexia, weight loss, a fluctuating organic mental syndrome, and recurrent episodes of loss of consciousness, each attack preceded by a period of dizziness and ataxia. After the patient had discontinued his work, serial electroencephalograms showed progressive clearing of focal and paroxysmal abnormalities, correlated with clinical improvement. It is noted in the text--and commented editorially, in the same journal, pp. 1248-1249--that unless the occupational history is carefully taken, the different diagnoses can be difficult. The patient under discussion had received anticonvulsant therapy for 2-1/2 years previous to the correct diagnosis. It is noted in the editorial also that there were a few more attacks which were always associated with driving a farm tractor. It was found that the patient had a habit of walking behind the tractor where the exhaust was on a level of about his head. When this occupation was also discontinued he recovered fully, and the diagnosis was confirmed. - APCA 3185

791. Hall, D.A., Miller, F.A., Riley, E.C., and Scherberger, R.F.: Evaluation of the carbon monoxide hazard from indoor use of propane-fueled fork lift trucks. Amer. Indust. Hyg. Ass. Quart. 18:355-359 (Dec.) 1957.

Carbon monoxide concentrations within industrial buildings can be reduced by using electric fork lift trucks, general ventilation, local exhaust, catalytic units, or by substituting propane for gasoline. As far as the carbon monoxide hazard is concerned, propane-fueled trucks offer a compromise between gasoline-fueled and electric-powered trucks. A well-tuned propane-burning engine should discharge less than 0.1% of carbon monoxide at the exhaust outlet as compared with 1.5% in the exhaust gas from a well-tuned gasoline-fueled engine and 6 to 7% from an engine not properly tuned (a more common case). - APCA 1635

792. Henderson, Y., and Haggard, H.W.: Health hazard from automobile exhaust gas in city streets, garages and repair shops. The vertical exhaust as a practical measure of amelioration. J. AMA 81:385-391 (Aug. 4) 1923.

The air in city streets where there is considerable traffic is found to be contaminated with automobile exhaust gas to a degree in excess of proper and well established health standards. The amount of visible smoke is not an index of carbon monoxid content.
The conditions in garages and repair shops are, as a rule, extremely unhealthful. Many mechanics and drivers suffer almost daily partial asphyxiation with headache and other sequelae.

Fatal asphyxiations in private garages are fairly common occurrences in the winter.

The conditions in the streets of American cities can be largely ameliorated by the use of the vertical exhaust on omnibuses, trucks, taxicabs, and private cars with tops. Cars without tops are now negligible in numbers in cities.

The horizontal exhaust now generally used mixes the gas throughout the respiratory zone of street air in a layer only about 10 feet deep. It thus dissipates the heat of the gas and prevents it from rising out of the street. The vertical exhaust, on the contrary, starts the hot gas upward with comparatively little admixture of air, and its heat carries it on up out of the street.

With the horizontal exhaust the entire air of the garage is rapidly mixed with exhaust gas. Adequate ventilation of garages is at present virtually not feasible. With the vertical exhaust, the heat of the gas holds it against the ceiling with comparatively little admixture of air, and the gas therefore readily finds its way out through any ventilator in the roof. - Authors' Conclusion

793. McBay, A.J.: Carbon monoxide poisoning. New England J. Med. 272:252-253 (Feb. 4) 1965.

Medicolegal problems in regard to death by carbon monoxide are discussed. Author states that the most puzzling cases are those produced by motor-vehicle exhaust fumes. About half of the fatal poisonings in the U.S. are attributed to CO, and many chronic sublethal poisonings by this gas are unrecognized. Exhaust of the gasoline engine may produce up to 7% CO. Exhaust of an automobile will saturate the interior of a small garage in 15 to 30 minutes with a lethal amount of CO. The affinity of CO for hemoglobin is 200-300 times greater than that of oxygen. Fatal poisoning may occur with a blood saturation of 30 or 40% of CO. Symptoms are not striking enough to make diagnosis easy. The much discussed pink color of the skin is rarely seen and the only valid test is the determination of the amount of CO in the blood. -AGC.

794. Mayers, M.R.: Studies in Carbon Monoxide Poisoning. New York State Dept. of Labor, Div. Indust. Hyg. & Safety Standards, 1946, 64 pp.

This pamphlet contains six papers on the following subjects:

1. Carbon Monoxide Poisoning
2. Effects on Red Blood Cells
3. Carbon Monoxide Headache
4. In Garages'
5. In Hat Industry
6. In Foundries

Author states that there is need for further study of the toxicological effects of mixed gases, in which CO is one of the constituents, on both animals in the laboratory and on workers in industry.

Although it is assumed that, while the principal action of CO is undoubtedly the production of anoxemia by displacing oxygen from the hemoglobin of the red cells, it may in addition, have other physiological effects not yet fully understood. Whether CO is a tissue poison is still another matter for further investigation. - AGC

795. Monaco, B.: Intoxication from carbon monoxide and CO determination and investigations in a large workshop producing city gas. Rass. Med. Indust. 33:495-527 (Sept.-Oct.) 1964.

Author reviews investigations carried out in a plant where working conditions were quite satisfactory with regard to CO concentractions, working hours and time of exposure. During two years of effective control no acute form of CO intoxication occurred under normal working conditions, however occasional cases of acute poisoning were observed in newcomers. Author did not observe chronic cases of CO poisoning and draws the conclusion that this type of CO poisoning is nonexistant. Moreover, he believes that persons regularly exposed to moderate amounts of CO become immune. Author also states that MAC values accepted in the USA are adequate, those of Great Britain and of the USSR seem to be too restrictive. - AGC

796. Nevers, G.F.: The carbon monoxide health hazard in automobile garages. Conn. Health Bull. 73:139-142 (May) 1959, and Indust. Hyg. Digest 23:14 (July) 1959.

One of the most common occupational exposures to CO as occurring in automobile repair garages is discussed in this paper. When breathed in less-than-fatal concentrations carbon monoxide causes severe headaches, mental dullness and a general feeling of malaise. An idling automobile engine produces about 7 cubic feet of exhaust gas per minute containing about 5% carbon monoxide, sufficient to exceed the maximum allowable concentration of 100 ppm in a relatively short time in most garages without adequate control measure. The removal of once dispersed carbon monoxide by means of general ventilation alone is usually impractical because of the prohibitive cost of heating replacement air. Control of the exhaust gases should be accomplished by means of local mechanical exhaust systems, whenever motor vehicle engines are operated in a fixed position for engine tuneup, carburetor adjustment, or other purposes. Such a system should include an exhaust fan, main suction duct, and an adequate number of flexible hoses attached to the tailpipes of motors in operation. The positioning and general traffic of cars within garages sometimes results in a buildup of carbon monoxide even though adequate tailpipe exhaust facilities are employed. A moderate amount of general ventilation, approximately three air changes per hour, will usually suffice to prevent a significant exposure from this source provided good supervision of extraneous engine operation is provided. - AGC

797. Trompeo, G., Gaido, P.C., and Capellaro, F.: Concentrations of carbon monoxide in the air and carboxyhemoglobinemia (study on garage mechanics). Rass. Med. Indust. 33:440-442 (May-Aug.) 1964.

Measurements have been made of the carboxyhemoglobinemia in workmen in an underground garage at the end of a working day. The average of the values was found to be higher than those of smokers who were not to other sources of carbon monoxide and in addition it was possible to note a close relation between the maximum carboxyhemoglobinemia values and values of CO in the surroundings. - Authors' Sum.

798. Trompeo, G., Turletti, G., and Giarrusso, O.T.: Concentration of CO in underground garages. Rass. Med. Indust. 33:392-393 (May-Aug.) 1964.

The results are reported of an examination of CO concentrations in the air of 12 basement or underground garages. The average concentration was found to be very near the MAC (according to the American standard) with values fluctuating between 10 ppm and 300 ppm. In view of the long day of over eight hours of garage employees, these concentration could therefore be responsible for possible processes of chronic carbon monoxide intoxication. - Authors' Sum.

799. Val'chuk, N.K.: Carbon monoxide in typical auto-tractor machine shops. Gigiena i Sanitaria 24:271-275, 1959. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 7, 1962, pp. 271-275, CFSTI-TT-62-11103, U.S. Dept. of Commerce, Springfield, Va.

The presence of carbon monoxide was investigated in auto-tractor machine shops, by the microtitrimetric method. Samples were taken at the level of worker's breathing and 200 samples were analyzed. Table shows data of carbon monoxide concentrations which exceed in most instances consideraby the limit of allowable concentration in the air of working premises. Carbon monoxide concentrations exceeded six to 9 times the allowable concentrations in the air of these premises when engines were tested under heavy loads or so-called "hot burnishing". Considerable improvement of the ventilating systems in the working premises of the motor machine shops was recommended. - AGC.

800. **Vaskevich, D.N., Bulycheva. A.I., and Mel'nikova, P.A.: Rapid method for the determination of carbon monoxide in the air of working premises. Vodosnozhenie i Sanitarnaya Tekhnika, No. 1, pp. 12-13, 1956. In: Levine, B.S. (translator and editor): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. U.S. Dept. of Commerce, OTS 62-11103, Washington, D. C., Vol. 7, 1962, pp. 97-101.**

Present method used for carbon monoxide determination is based on the oxidation of carbon monoxide to carbon dioxide by iodine pentoxide, presents considerable difficulties when it becomes necessary to collect and analyze many air samples in a short time. The authors describe an indicator method for the determination of low carbon monoxide concentrations in the air of production premises, an improvement over the present complicated procedure. The method described in detail is based on passing the test air for 3-5 minutes through an indicator tube filled with a special white powder. As the CO passes through the tube, the powder acquires a greenish violet color, the intensity of which is proportional to the CO concentration in the air. The intensity of the developed color is then compared with the color of a specially prepared standard series of tubes representing CO concentrations in the range of 0.01-0.4 mg/li. The procedure requires 10 minutes and the determination can be made directly on the spot. Table shows comparative data of CO determinations by standard method and by the new indicator method. - AGC

801. Kaye, S.: Carbon monoxide poisoning. Virginia Med. Monthly 84:627, 1957.

This short one page paper relates the properties, general signs and symptoms, and treatment of carbon monoxide poisoning. Author also states that most common exposures are from exhaust of gasoline engines in enclosed spaces, and he relates that deaths have occurred by exposure in an open canopy cruiser at sea during a calm. The following toxic levels are given:

% Carboxyhemoglobin:
Below 5%--usually no symptoms.
Below 20%--mild symptoms.
Above 20%--moderate to severe symptoms.
Above 40%--may produce coma and death.

- AGC

802. Yant, W.P., Jacobs, W.A., and Berger, L.B.: Carbon monoxide poisoning in private garages. Indust. Eng. Chem. 16:1047-1049 (Oct.) 1924.

Two methods employed in an analysis of the contaminated air in garages are described:

1. The known volume of CO liberated by the engine per unit time, together with the ventilation (usually expressed in air changes per hour), the resulting composition of the air in garages after

an interval of time can be readily calculated. The results of this calculation can be made applicable to all sizes of garages, types of automobiles, and ventilation conditions.

2. Analysis can be made of the contaminated air of a garage in which an engine is actually running.

Both methods were used in the work described in this paper. However, more attention has been given to the former, because the results can be made applicable to all sizes of garages, types of automobiles, and ventilation conditions; whereas by the latter method, the results only pertain to the particular set of conditions under which the tests were made. - From Text-AGC

Gasoline Engines

803. Automobiles and air pollution. J. AMA 162:134 (Sept. 8) 1956.

In a report of the Fuel Research Station to the Royal Society of Health, England, it is pointed out that air pollution caused by automobile exhaust gases is small compared with that caused by coal combustion; however, since vehicular exhaust gases are emitted in the streets at a low level, there is little chance of their being dispersed before being inhaled. In gasoline engines, the carbon monoxide emitted is about 4%, and in diesel engines about 0.1%. Practically no benzopyrene is detected at gasoline engine loads exceeding 50%, while in efficiently run diesel engines only a trace is evident. Yearly pollution from carbon monoxide totals 24 metric tons of which 10 tons are from industrial chimneys, 10 tons from domestic appliances, and 4 tons from automobile exhausts. The average carbon monoxide in the air of London streets in 1955 was 15 ppm. In the smog of Jan. 1956, the carbon monoxide content rose to 50 ppm in London and 80 ppm in Salford, England. Data indicate that the average pedestrian experiences an effect of carbon monoxide poisoning at a concentration of 50 ppm after exposure of 4 to 8 hours. - LC

804. Barrett, H.M.: Carbon monoxide poisoning. Canadian J. Pub. Health 25:430-438, 1934.

Carbon monoxide accounts for more human deaths annually than all other gaseous poisons combined. Its occurrence is almost universal, resulting as it does from incomplete combustion. Industrially carbon monoxide occurs in high concentration in smelters, being a major hazard in steel plants. It is to be guarded against in mines after an explosion or blasting operations. In the home it is the responsible factor in coal gas poisonings due to faulty heating appliances. The automobile produces the gas in large quantities and it is present in varying quantities in public garages. A car with the motor idling in a closed single garage produces sufficient of the gas to render the air dangerous in from five to ten minutes. It is one of the most insidious poisons known as it is odourless (except in the nearly pure form when it possesses a faint garlic odour) and produces no irritating symptoms. For these reasons a knowledge of its mode of action and methods of determining its presence are of paramount importance. - Author's Introduction

805. Barth, R.: Investigations on the CO content of the air in motor vehicles. Deutsche Kraftfahrtforschung und Strassenverkehrstechnik No. 142:1-12, 1960.

On account of its great affinity to the red blood pigment, the colorless and odorless carbon monoxide gas (CO) is particularly toxic for the human organism. Due to the incomplete combustion which takes place in the engine of the vehicle, it is contained in varying concentrations in the exhaust gases of which traces can penetrate into the passenger area of the car due to a lack of tightness in the bodywork or unsuitable heating and ventilation systems. By reason of the presence of various gas constituents even a CO content of less than the maximum permissible quantity of 0.01% may be annoying in the car and have a detrimental effect upon driving safety.

During driving tests made under defined conditions, samples were taken of the inside air in series-production motor vehicles and the CO-content thereof was determined. In the tests due consideration was given to the influence of the arrangement of the exhaust of the heating system and to possible leaks, the speed of travel (load imposed upon the engine), the ambient atmosphere and the pressure conditions created by the air stream. - Author's Abst.

806. Baulmer, J., and Muller, R.: The estimation of motor car exhaust gases in street air. Z. Preventive Medicine (Zürich) 6:10-23 (Jan.-Feb.) 1961.

After reviewing the important toxic gases emitted in the exhausts from motor cars, the methods used in examining the air in the streets and garages of Basel, Swit. are described and the results reported. Carbon monoxide, determined with the recording Drager-CO-apparatus, was found to be present in streets with heavy traffic at a level up to 0.003 vol.%. The concentrations in a subterranean garage were sometimes higher than 0.01 vol.%. A transportable apparatus for the sampling of exhaust gases from motor cars (formaldehyde, nitrogen oxides, ammonia, sulfur dioxide) is described and some further results of air pollution in the streets of Basel are given. - APCA 6272

807. Besson, A., Girbal, E., Mosinger, M., and Jullien, G.: Study of the pollution by carbon monoxide at various street intersections in Marseille. Bull. Academy Natl. Med. (Paris) 146:368-374 (May) 1962.

Marseille is a large city with a population of over 800,000 inhabitants living in an area 23,000 hectares (compared to 10,000 hectares for Paris) and is stretched along the coastline. The number of motor vehicles being driven in the city are increasing all the time, with the number estimated at 51,000 on Jan. 1, 1951 increased to 138,000 on Jan. 1, 1961. The number of motor vehicles--including the automobiles of tourists, the utility vehicles, and busses--registered in a large parking facility on a day in Jan., 1962 exceeded 150,000. When it is estimated that 2/3 of these motor vehicles are circulating daily within the city, then 100,000 motor vehicles, using both gasoline and diesel oil, are contributing to the atmospheric pollution. The poor combustion of fuel in the motors results in the production of large amounts of carbon monoxide. This gas is a very toxic one but one which, though very heavy, diffuses rapidly in the atmosphere. The exhaust gas of an auto produces about 12-13% of carbon monoxide. Under controlled running conditions a motor emitting 12% of carbon monoxide would produce about 6 $m.^3$ of carbon monoxide/hour. It has been estimated that at 1 point in the traffic pattern of Marseille, automotive vehicles produce about 600,000 $m.^3$ of carbon monoxide/hour. Samples of air were collected and their carbon monoxide content determined at 7 street intersections between the dates of Dec. 18 and March 7, (1961?). At no time did the total content of the atmosphere attain a level of 1/10,000 (100 ppm.) which would correspond to the toxic threshold. The maximum attained was 0.7/10.000. At 5 different times at 1 location and 2 times at 2 other locations, the level reached 0.5/10,000 or slightly above. At 1 intersection it was never observed higher than 0.32/10,000. - APCA 5083

808. Bloomfield, J.J., and Isbell, H.S.: The problem of automobile exhaust gas in streets and repair shops of large cities. Public Health Rep. 43:750-765, 1928.

In 14 large U.S. cities from Boston to San Francisco, having a combined population of 19,000,000, a survey was undertaken to determine the degree of health hazard, if any, due to CO from car exhausts. 250 air samples were taken and analyzed, 141 of them between 4:00 and 6:00 p.m. They were collected at breathing level of pedestrians at intersections with congested traffic, in tunnels for both cars and pedestrians, in taxicab stations, in buses and in houses opening on congested streets. A total of 102 air samples were taken in 2 car repair shops/city. All pertinent and modifying factors were recorded with the values obtained. Analyses by use of the I_2O_5 determination method, using a liquid air cooling tube, revealed the following CO contents (given in ppm): in the streets - average: 80, average ranges: 20-290. 24% of the samples taken in the streets showed >100, 1 contained 200. The values given for CO contents in the air of repair shops averaged 210, with average ranges of 10-1,100. 59% contained >100, 18% >400. 7 samples collected in buses contained an average of 50; the average ranges given are 10-100. The CO concentration on the first floor of several buildings is given as 40, while on the 4th floor, 30 were found. The CO contents of the air samples taken in the streets is not considered representing any health hazard. The potential hazard for the policemen could be diminished by reducing the time of exposure at intersections with congested traffic. The CO concentrations found in the repair shops, however, indicate a dangerous condition, and they also demonstrate that there is an even greater danger present in the small private garages. The motors of cars should not be run longer than 30 seconds unless the car is in motion or equipped with suitable exhaust outlets. At any rate, the discharge of exhaust gases into roofed enclosures should be avoided. - Kett. 13

809. Bolt, J.A., and Boerma, M.: The influence of inlet air conditions on carburetor metering. Presented at the Automotive Eng. Congress, Detroit, Mich., Jan. 1966, SAE Paper No. 660119.

The fuel/air ratio is a predominant factor in the quantity of unburned hydrocarbons, carbon monoxide, and oxides of nitrogen in the exhaust of gasoline engines. Therefore carburetor metering accuracy takes on added significance in view of the mounting interest in air pollution.

This paper provides data concerning the enrichment of automotive carburetors with variation of inlet air pressure and temperature. These changes occur with weather and the seasons, with altitude, and because of underhood heating. The early opening of the conventional carburetor enrichment value at altitude can add greatly to the "normal" carburetor enrichment. Means for compensating the mixture ratio for these changes in inlet air conditions are known, but will almost certainly add to the complexity and cost of the engine induction system. The cost of improved devices must be compromised with the possible reduction in exhaust emissions and improvement in fuel economy. - Authors' Abst.

810. Brice, R.M., and Ludwig, J.H.: The distribution of vehicular air pollution in the United States. USPHS, Div. Air Poll., Cincinnati, Ohio, June, 1965.

The contribution of automotive vehicular emissions to air pollution and the magnitude of the effects of these emissions have been well documented in Los Angeles County and to a lesser extent throughout the State of California. Data are presented which show the presence of photochemical "smog" in a number of communities outside California. The severity and prevalence of "smog" in eastern communities is not as high as in Los Angeles, however, evidence from most large cities where atmospheric pollutants have been measured shows some photochemical activity with production of oxidants throughout the year and severe "smog" when adverse meteorological conditions occur. Plant damage of the types associated with photochemical pollutants has been observed in many areas throughout the country and further indicates the presence of adverse levels of motor-vehicle-derived pollutants. Source surveys in a number of cities in the United States show that motor vehicles are responsible for very appreciable amounts of the total emissions of hydrocarbons, nitrogen oxides, and carbon monoxide.

The facts presented clearly point to potential problems under current conditions and problems of increasing severity as population densities and use of motor vehicles increase. -Author' abst.

811. Brief, R.S., Jones, A.R., and Yoder, J.D.: Lead, carbon monoxide and traffic, a correlation study. J. APCA 10:384-388 (Oct.) 1960.

Atmospheric levels of lead and CO were studied at 6 locations in a northeastern US city (unidentified) with traffic densities ranging from 0-99 vehicles/minutes. Sampling site: 30-50 feet from nearest traffic, 4 feet above ground level. Sampling method for CO: ambient air at 100 cc/minute, filtered through a silica gel trap and then into 3 commercially available CO indicator tubes in parallel. Sampling schedule: The program was operated 5 days a week, Thursday through Monday, during a 3-week period in July and August, 1959. Sampling started at 10:30 AM and continued through 6:30 PM each day. Each of the 6 sampling locations was used 5 times. Traffic density was averaged from seventeen 5-10 minute counts during the 8-hour day. CO concentration correlated with traffic density at 99% significance; CO (ppm) = -0.281 + 0.136T (vehicles/minute). Range of CO concentrations:

1)	Light traffic (0-5 vehicles/minute)	0-1 ppm
2)	Moderate traffic (3-22 vehicles/minute)	0-6 ppm
3)	Heavy traffic (16-99 vehicles/minute)	0-47 ppm

- LEPS

812 Byrom, R.D.: Defense against CO - the silent killer. Eng. & Min. J. 158:88-89 (Oct.) 1957.

Carbon monoxide is a colorless, odorless, and tasteless gas. And since human perception of it comes only from its poisoning effect, practical detection is only by instrument.

It is lighter than air. Therefore it gathers in high points such as at tops of raises, stopes and buildings.

It is a product of incomplete combustion and is found to some extent in all smoke and fumes from burning carbonaceous material, as in furnaces, blasting fuses and explosives, fires, and internal combustion engines.

It is virtually insoluble in water--30 ppm. Therefore, water sprays and scrubbers will not remove it from air. Usual requirement is to dilute it with large volume of air, although at least one engine exhaust conditioner (Oxy-Catalyst, Inc., Wayne, Pa.) uses a catalyst which when heated oxidizes CO to CO_2. Legal minimum air requirements are usually 75 cfm per hp.

It is taken up by blood at expense of oxygen, thus causing oxygen starvation. - Author's Abst.

813. Caplan, J.D.: Causes and control of automotive emissions. In: Air Pollution Control. Hearings before a Special Subcommittee on Air and Water Pollution of the Committee on Public Works, United States Senate, 89th Congress, 1st Session on S 306, April 1965, U. S. Government Printing Office, Washington, D. C., pp. 160-171.

The sources and composition of emissions from gasoline-engine vehicles are described, the causes are elucidated, and the importance of specific components of the emissions is discussed. Methods of reducing the emissions from the various sources are presented along with an evaluation of their respective merits and limitations. In addition, the need for additional research concerning the importance of specific emission components is explained. Finally, the Automobile Manufacturers Association's co-operative programme for vehicle emission control is discussed. - Author's Abst.

814. Di Lullo, G : Pollution by carbon monoxide of urban air in relation to traffic of vehicles with combustion motors. Nuovi ann. igiene e microbiol. (Rome) 11:141-153 (March-April) 1960.

Studies were made of the concentration of CO at various locations in the city of Naples. It was found that at three locations with heavy traffic and in one where it was extremely heavy, the concentrations ranged from a trace to 150 ppm. In a series of determinations at 19 different locations in the vehiculer traffic tunnels of the city there were a few observations of no CO present but mostly the concentrations ranged from 50 to a high (in 3 locations) of 200 ppm. Quoting from an earlier paper by a co-worker, the author gives CO concentration ranges of 10-300 ppm. for New York City; 10-[illegible] for Paris; 0-200 for Berlin; 4-40 for Dresden; and 1-200 for Budapest. - APCA 3999

815. Drawin, H.W.: Mass spectrometric analysis of auto exhaust and air pollutants. Automobiltechnische Zeitung 62:104-109, 1960.

With an electric or magnetic field arrangement mass spectrometry permits the separation of ions in space and time, according to their ratio of mass to electric charge. The substance to be investigated has to be put into the ion sources in the form of gas or vapor. The ion streams, in proportion with the concentrations of the components, are measured by oscillagraphy. When investigating auto exhaust it can be directed through a pipe line to the mass spectrometer. It is to be observed that the condensating components (approximately 15%) are not lost to the analysis because this would falsify the results. The usual instruments are to be equipped with reheat devices up to 180°C, auxiliary attachments even up to 350°C. By other methods of sampling an evacuated glass flask can be used. Mass spectrometry is also suitable for the analysis of other air pollutants. - AGC

816. **Effenberger, E.: Exhaust gas hazards to passport and customs officials at border areas. Z. Hyg. Infecktionskrankh. (Berlin) 145:403-421, 1958.**

Carbon monoxide concentrations at the breathing zone of customs officials close to idling vehicles was found to average 78 and 130 ppm at the two stations tested. During heavy traffic under meteorological conditions favoring accumulation of exhaust gas, peak values reached 220 and 240 ppm. Traffic density was recorded and regressions of carbon monoxide on traffic density at the two stations were as follows:

T being traffic density in cars per minute.

$$\text{ppm CO} = -37.2 + 30.0T$$
$$\text{ppm CO} = +6.6 + 20.2T$$

Differences in the meteorological conditions and structures at the two stations accounted for the differences in the regressions.

817. Erdmann, H.: Engine exhaust gases and toxicology. ATZ (Automobiletechnische Zeitschrift) 62:325 (Dec.) 1960.

This paper is a review of the Conference of International Transportation "Rails and Roads" held Sept. 1960 in Essen, Germany, at which the problem of exhaust from Otto engines was discussed. Otto engines discharge more toxic exhaust gases in low gear and idling, than in high gear. These exhaust gases contain following injurious components: carbon monoxide, incombusted hydrocarbons, nitric oxides, sulfur, lead and soot. These have been split and partially combusted in the engine. Carbon monoxide can be reduced by careful adjustment of the carburetor. Due to the geographic location and due to the fact that a large number of vehicles are operated by Otto engines, Los Angeles suffers severely under this type of air pollution. - AGC

818. **Faith, W.L., Renzetti, N.A., and Rogers, L.H.: Automobile exhaust and smog formation. Air Poll. Foundation Rept. No. 21, 1957.**

This report summarizes the work done to date and discusses the obstacles that still hinder an effective solution. It should serve as background data for scientists and engineers unfamiliar with the details of the problem. The following topics are covered: (1) Relationship of automobile exhaust to smog. (2) The internal-combustion engine. (3) Nature of auto exhaust. (4) Atmospheric analyses. (5) Analytical methods and testing procedures. (6) Control methods for auto exhaust. (7) Legal and enforcement problems. - APCA 1531

819. Faith, W.L.: Automobile exhaust control devices. J. APCA 13:33-35 and 39 (Jan.) 1963.

The nature of control devices depends on legislation set up by the California Motor Vehicle Control Board. The chemical requirements or emission standards for exhaust gases are: not over 1.5% by vol. carbon monoxide and 375 ppm. hydrocarbons. For crankcase blowby gases, hydrocarbon emissions are limited to 0.15% of the fuel supplied to the carburetor. These values reflect approximately 80% reduction of hydrocarbon emissions and 60% reduction of CO emissions. Specified criteria for life and safety devices, effect upon engine and vehicle performance, odor, noise, toxic, or noxious contaminants, the effect of these criteria, the degree, and the type of pollution required are discussed. - APCA 5185

820. Field, F., and McGuire, J.K.: The need for more meaningful meteorological and air quality observations for mortality and morbidity studies. In: Air Over Cities. Symposium, SEC TR A62-5, USPHS, Cincinnati, Ohio, 1962, CFSTI PB-167 552, pp.277-290.

Author expresses in this paper the need for more knowledge on the interaction between pollutants in the atmosphere and between pollutants and weather elements. Observational and experimental evidence indicates that the toxic effect of CO, a pollutant, is enhanced by higher temperature, a meteorological element. In order to study more specific forms of illness, further investigation is needed to ascertain the role played by weather in transforming or altering pollutants in the photochemical reactions, in the absorption of gases and vapors on particulate material, and in catalytic oxidation and other chemical and physical changes. - AGC

821. Fitton, A.: Air pollution from road vehicles. Smokeless Air 25:152-154 (Spring) 1955.

The author compares concentrations of pollutants (carbon monoxide, hydrocarbons, aldehydes, oxides of nitrogen, and sulfur dioxide) from gasoline and diesel engines. Analyses show that in traffic areas the CO concentration is 10 to 20 times that found in areas with little traffic. A similar situation occurs in badly ventilated garages, and the degree of pollution is a good test of the adequacy of ventilation. Although the average figures for pollution are lower for the diesel than for the gasoline engine, the diesel tends to discharge far more carbon or soot than the gasoline engine. While the condition of the engine and vehicle is of some importance, recent research shows that (comparing 1940-1942 cars with 1950-1951 cars) there is no appreciable difference in the hydrocarbon discharge during acceleration and cruising. When the engine is idling or decelerating, however, there is a considerably higher hydrocarbon discharge from the older car. The average figures for CO content for four modern American cars, gasoline driven, were: accelerating 4.7%, cruising 3.0%, decelerating 2.7% and idling 5.7%. - APCA 416

822. Georgii, H. W., and Weber, E.: Investigation of carbon monoxide emission in a large city. Internat. J. Air & Water Poll. 6:179-195 (May-Aug.) 1962.

This paper discusses continuous records of the carbon monoxide concentration of the air gained at different sampling stations with different traffic intensity in the city of Frankfurt, Ger. The method applied for these measurements was nondispersive ultrared-spectroscopy. The diurnal trend of the CO concentration is mainly influenced by the fluctuation of the traffic during the day. The absolute CO values found are primarily determined by wind velocity, wind direction, and traffic density. The results show that a wind velocity of 3 m./s. or more lead to an efficient dispersion of the automobile exhaust gases within the streets. The investigations show that the automobiles are the only important source of CO in the city, and they are supplemented by measurements in 1 of the recently constructed parking garages and finally deal with preliminary results of the vertical distribution of CO above the streets. - APCA 4823.

823. Giubileo, M.: The pollution of city atmospheres caused by motor vehicles. Riv. Combustibili (Milan) 11:157-166 (March) 1957.

Atmospheric pollution due to motor vehicle exhausts was investigated in Milan. Carbon monoxide content in exhaust gases ranged from 0.1 - 8.4%, and compounds from tetraethyl lead were determined. In the central streets the maximum concentration of carbon monoxide was 80 - 100 ppm. and 80 ppm. in tunnels. Lead in the street air was 2.4 - 7.4γ/m.^{3} of air, and in street and garage dusts 0.23 - 5.22 mg./g. The carbon monoxide and lead concentrations were due to amount of local traffic. Pollution from motor vehicles in Milan is comparable to that existing in other cities, and the present concentrations of CO and Pb in atmospheric air are considered harmless. - APCA 1409

824. Giubileo, M.: Researches on pollution of the atmosphere of cities caused by motor vehicles. Minerva Med. 49:1051-1054 (March 21) 1958.

Studies were made of the contamination of the atmosphere of Milan from motor vehicle traffic by either carbon monoxide or lead oxide. Given in the text are 2 tables, one of which indicates the vol. % of CO, CO_2, and O_2 found in the exhaust gas of a 2-cylinder motorcycle, a 4-cylinder Fiat run on gasoline, and both a small and a large (4- and 6-cylinder) motor vehicle each with a diesel motor. In each case, the motor was run at 2 different speeds during each of 3 tests. The amount of CO in the exhaust gases was found to vary from 0.6 to 8.4% for the other motors and 0.1 to 0.4% for the diesel motors. The CO content of the air of the streets in the center of the city ran as high as 80-100 ppm.; above

40 ppm. in the semi-central areas; and from 40-80 ppm. in the mid-sections of 2 tunnels. Lead fumes in the air were found to be in a concentration of 5.4-7.4 γ/m^3 in the central areas; of 3.6 γ/m^3 in the semi-central area; and of 2.4 γ/m^3 around the periphery of the city. Thirteen determinations on lead content of street dust revealed the highest content to be 2.24-2.36%. A high value of 8.1 mg/m^2 was found to have been built up during the course of the day. The quantity of CO and of Pb in the air, and of Pb in dust appeared in several instances to be less elevated when the traffic was intensified, resulting evidently from the increase of the dispersion factor of the air. Since the concentration of the CO in the city streets is usually not unduly high, the toxicity depends heavily on the period of exposure. Exposure to concentrations of 100 ppm. for any length of time could be expected to cause cephalic symptoms, nausea, and vertigo. A dust content of the air of 5 $mg./m^3$ above an asphalt street could be expected to bring about a content of lead of about 10-20 γ/m^3, an amount which is well below the limit of tolerance. The concentration of CO and of lead in the atmosphere of Milan is in the range which exists in other large cities of Europe and America, and is among the highest found in Italy. Clinical examinations of 20 urban residents indicated a carboxyhemoglobinemia of 0 to 10% (average, 4%); of plumbinemia of 20-90 γ% cc (average, 45 γ); of plumbinuria of 30-135 γ/1. (average, 55 γ); and of coproporphrinuria of 0-3 γ% cc (average, 0.5 γ). The values are considered to be within the normal limits for residents of cities. - APCA 2863

825. Gofmekler, V.A., Manita, M.D., Manusadzhants, ZH. I., Stepanov, L.L.: Correlation between the concentration of 3,4-benzpyrene and carbon monoxide in the exhaust gases of motor cars. Gigiena i Sanit. (Moscow) 28:3-8 (Aug.) 1963.

The article presents results of analyses of exhaust gases for 3,4-benzpyrene and carbon monoxide content. The investigations were carried out with exhaust gases discharged by motor cars ZIL-164, and IAZ-51 operating under various conditions. In a running car the discharge of 3,4-benzpyrene decreases with the increase of the car's speed. The proper regulation of the carburetor lowered the discharge of incomplete combustion products and that of 3,4-benzpyrene and CO. A direct relationship was traced between the discharge of 3,4-benzpyrene and that of CO. - APCA 6013

826. Goldsmith, J.R., and Rogers, L.H.: Health hazards of automobile exhaust. Pub. Health Rep. 74:551-558 (June) 1959.

In Los Angeles, the air pollution from diesel engine exhaust is about 20 tons of organic emissions/day while that from automobile exhausts contributes about 1200 tons/day. Because the theoretical value (15:1) for air to fuel required for complete combustion is seldom maintained in automobiles, their exhausts frequently contain carbon monoxide, hydrogen, aldehydes, unburned hydrocarbons, sulfur oxides, and some lead compounds depending on the additives used. The constituents (in % of concentration, vol./vol.) of automobile exhausts are listed in table 1. Of these only carbon monoxide nitrogen oxides, lead compounds, and hydrocarbons are discussed in this paper. The max. CO concentration in Los Angeles, reported in table 2, is 93.2 ppm., with an average value of 15 to 36 ppm. British cities have reported an average of 4 to 20 ppm. with a max of 80 ppm. during smog. In Detroit, during heavy traffic an average of 28.9 ppm., with 80 ppm. max., has been reported. Although no health damage has been attributed to levels of CO below 100 ppm. there is undoubtedly some inactivation of hemoglobin. The level of CO saturation in the blood is greatly increased in tobacco smokers. Although experimental studies have shown an impaired adaptability of the eyes to darkness when young subjects were exposed to low levels of CO, this has not been shown by exposure to automobile exhausts at the levels found on city free-ways. It is, however, a plausible inference. The toxicity of nitrogen dioxide is based on its irritant properties, especially to the pulmonary membranes in cases of significant exposure, which are often delayed in onset. The nitrite ions formed when nitrogen dioxide dissolves are capable of forming the inactivated hemoglobin known as methemoglobin. Lead exposure by air pollution alone as reported by Los Angeles and other cities is usually not toxic but the small persistent amounts which could be contributed by auto exhausts may contribute to cases of toxicity in certain individuals working in garages and other work areas. Hygienic standards have been established for industrial exposure to CO, nitrogen dioxide, lead, and ozone. Establishing a full set of levels for community exposure is difficult because of the many variables involved, including the effect of agents in combination, the difference in sensitivity of ill persons, and the indeterminate period of exposure. The authors suggest that, in the absence of effective control for air pollution from automobile exhausts, the public health hazard should be evaluated. - APCA 2647

827. Goosens, J.F., and Lafontaine, A.: Chemical pollution of the air of modern cities and the particular problem of combustion gases from internal combustion engines and heating installations. Arch. belges méd. sociale hyg. méd. travail et méd. légale (Brussels) 16:217-237 (May) 1958.

After some consideration of the origin of air pollution of cities, something of its pathological effects, and its prevention, the authors concern themselves particularly with air contamination from motor exhausts. There is some discussion of the composition of the air over cities, including CO, SO_2, nitrogen oxides and peroxides, aldehydes, lead, etc., and for its possible, eventual, cancerogenic possibilities. Some preventive measures are suggested, among them (1) routing of motor traffic to the periphery in order to decongest the center areas of cities; (2) decentralization of industrial sectors and separation from areas of habitation to diminish the contamination and also to implant a screen of greenery; (3) acceleration of urban travel, reduction of entries into the city, and severe reduction of parking; (4) prevention of accumulation of exhaust gases in places such as tunnels, favoring instead of natural means of ventilation a permanent and automatic mechanical one; (5) institution of studies of the technical problems of prevention by perfection of motor combustion, and by reduction or neutralization or toxic substances by appropriate methods, together with assurance of surveillance and regulation of motors and combustion which would at the same time give an appreciable economy of operation; (6) institution of legislation and means for its adequate application in control of such pollution. - APCA 2591

828. Gunderman, K.O.: Hazards of the motorist by carbon monoxide. Stödtehygiene. 77:248-253, 1964.

The results of CO recording in the two large cities Kiel and Hamburg in Northern Germany, during rush hours show clearly that they are above the harmless limits of the industrial MAC of 0.01 Vol. %. These values which present the maximal limits at the present time in both cities, will most probably not be increased because of the relatively favorable climate of these cities. However, under climatic unfavorable condition the same traffic density may cause dangerous CO levels. The recorded CO concentrations may become, however, a severe threat to the health of the population in these two cities mentioned above, if traffic and with it the exhaust emission are being increased to the level as it prevails at present only a few hours during the day, for a considerable longer period of time. Additional danger to the motorist is caused by heavy smoking. It is strongly recommended to reduce exhaust gas emissions. It is also requested to keep traffic moving by enlarging roads, by planting greeneries on traffic islands, and through improvement of engine design. Of importance is also the construction along the roads which should not impede ventilation. These measures would also reduce the danger cause by other exhaust components, for example carcenogenic propertie However, chronic effects of long-term inhalation of various auto exhaust pollutants needs to be investigated further. Translation of sum. -AGC.

829. Haagen-Smit, A.J.: Carbon monoxide levels in city driving. Clean Air Quarterly 8:8-9, and 10 (Dec.) 1964, and Arch. Environ. Health 12:548-550 (May) 1966.

The purpose this study was to determine the concentration of CO which a Los Angeles rush hour commuter breathes while driving on the freeway. This was done by placing a CO measuring instrument and recorder on the passenger seat of a car and then driving it along the freeway during rush hours. Results of the test are summarized in a table. The time average includes time spent in heavy and light freeway traffic, and on Pasadena roads. According to California standards for CO, 30 ppm for eight hours or 120 ppm for one hour is a serious level of pollution. Author concludes that if a commuter spent two hours at the higher exposure level found in the study, his carboxyhemoglobin would be approximately that cited by the Department as serious. - ACC

830. Hagen, D.F., and Holiday, G.W.: The effects of engine operating and design variables on exhaust emission. SAE Paper 486C. Presented at the Combined National Automobile and Production Meetings of the SAE, March 12-16, 1962, pp. 41.

To determine the influence of engine variables on the composition of exhaust gas, engine dynamometer tests were conducted on single and multi-cylinder reciprocating engines. The following engine variables were investigated: air-fuel ratio, power output, engine speed, spark timing, exhaust back pressure, valve overlap, combustion chamber deposits, and intake manifold pressure.

Hydrocarbon concentrations were found to be considerably affected by changes in air-fuel ratio, spark timing, intake manifold pressure, and combustion chamber deposits. Somewhat less change in hydrocarbon concentration was obtained by varying valve overlap and engine speed. Changes in engine power output and exhaust back pressure had little effect on hydrocarbon concentrations.

Carbon monoxide concentrations were principally affected by changes in the air-fuel ratio. No other variables affected carbon monoxide concentration except where air-fuel ratio was indirectly influenced.

The influence of changes in the variables on hydrocarbon and carbon monoxide emissions in pounds per hour was also determined.

Vehicles were tested on the road and chassis dynamometer to investigate the effect of air-fuel ratio, spark timing, and valve overlap on hydrocarbon and carbon monoxide concentrations. Carburetion leaning, spark timing retardation and reduction of valve overlap produced concentration reductions in line with those predicted from engine dynamometer studies. - Authors' Abst.

831. Hajek, F.: How motor vehicles pollute the atmosphere of cities. Silničmí Doprava (Prague) 12:4-7, 1964.

The Transportation Res. Inst. measured CO and CO_2, using 2 infrared analyzers at 8 different locations on heavily-traveled streets in Prague in Sept.-Oct. 1962. The concentrations were recorded on a moving chart. Wind velocity was also measured every 15 min. at each test site. The measuring devices were set up on the sidewalk near the curbs at a level approx. the height of an av. pedestrian. The numbers of automobiles, trucks and motorcycles passing by the test sites were counted and the numbers recorded on the charts. The CO_2 concentration did not exceed 0.2% at the peaks and varied in general between 0.1 and 0.15%. Interesting findings were obtained at the Letensky tunnel, at both the entrances and exits of the uphill and downhill roadways. Unfortunately the tunnel is not self-ventilating as its planners had assumed it would be. In the tunnel where it goes downgrade into the center of the city, the CO concentrations were found to reach several peaks of 0.008% to 0.010% (80 to 100 ppm.) during periods of heavy traffic at 9:00 to 11:00 A.M. and 4:00 to 8:00 P.M. A traffic policeman stationed at the exit from this tunnel, during a hot and calm day, had to leave his post because of severe headaches and general malaise. Even during the heaviest traffic in streets which were along an east-west axis (which was that of the prevailing winds) there was no appreciable rise in CO_2 and CO concentrations. In contrast, the heavily-traveled streets on a north-south axis were badly polluted. The proximity of a steam locomotive railway station added to the pollution in 1 of these areas. Since the max. amounts of CO are produced in automotive exhausts during deceleration, acceleration, and idling at intersections, the author suggests that the traffic flow should be directed in such a way as to reduce stopping to a min. by making the streets 1-way speedways during rush hrs. Automobile carburetors should be properly adjusted. Heavily polluted areas, where there is not sufficient air circulation--especially in the hot, windless calm of summer days--should be sprayed with water from spray trucks. Such a fine water-spray would wash down a large portion of the pollutant material. - APCA 6794

832. Hama, G.M.: Truck and bus exhaust. Indust. Hyg. Quart. 11:30-33, 1950.

Probably the most frequently encountered atmospheric pollution is that from buses and trucks. The sickening fumes associated with bus riding, the obnoxious odors coming through automobile fresh-air heaters, and the burning sensation in eyes and nose at certain traffic intersections are typical examples of exposures to bus and truck exhausts. This pollution is extremely obnoxious and disagreeable and causes a feeling of illness and nausea in some individuals.

On busy city streets it is possible the carbon monoxide content of the air may exceed the maximum allowable concentration of 100 parts per million parts of air. However, as this concentration is based on an 8-hour exposure, the average citizen will not suffer discomfort or ill health. - BMB 404

833. Hass, G.C.: The automobile as a source of air pollution. Trans. Soc. Agr. Engrs. 4:142-143, 1961.

Although much intensive study has been done on the smog situation in Los Angeles the phenomenon is still defined in terms of gross effects. Among the effects are those of eye irritation, aerosol formation, ozone formation, and damage to vegetation. A less well-known fact about automotive air pollution is that the concentrations of carbon monoxide in the atmospheres of poorly ventilated cities are approaching levels at which public health agencies are beginning to be concerned about the physiological effects. For all practical purposes, automotive vehicles are the only significant source of atmospheric carbon monoxide. Although the principal point of emission from a motor vehicle is the tail-pipe, there is also some emission from the crankcase vent, and from the carburetor and fuel tank. Since any scheme to artificially ventilate the air involves moving millions of tons by weight of air, other control methods have to be sought. Last year Los Angeles County adopted a rule requiring the gradual reduction of olefins in gasoline but the benefits are both controversial and costly to the car owner. Deceleration cut-off devices are available and, after further study, were found to be more effective than was thought earlier. Any radical change in engine design appears to be some years off. Major attention is now focused on the development of afterburners for the exhaust system, the 2 types being the catalytic scheme and the direct-flame afterburner. Many companies have such devices under development but the price, and cost of upkeep, are still indefinite. However, a device to control crankcase vent losses is available and inexpensive, and a method of reducing the emissions of oxides of nitrogen has recently been announced. On Dec. 4, 1959, the State Dept. Public Health of Calif. adopted standards of air quality and standards for motor-vehicle exhaust emissions. The 1960 legislature passed a new smog bill which provided for the establishment of a 13-man State Motor Vehicle Poll. Control Board. The bill states that after 1 year from the date on which the Board has certified 2 or more motor-vehicle pollution-control devices, all new cars sold in Calif. shall be equipped with such devices. The application of devices to used motor vehicles is a local option and a longer period of compliance is provided. - APCA 5086

834. Hass, G.C., and Brubacher, M.L.: A test procedure for motor vehicle exhaust emissions. J. APCA 12:505-509, 543 (Nov.) 1962.

The test consists of a prescribed sequence of vehicle operating conditions on a chassis dynamometer, with exhaust constituents being continuously recorded with infrared instruments. The test set-up is shown in figure 1. The driving cycle was evolved from the 11 driving modes specified in the standards for motor vehicle exhaust. The test procedure has proved to be useful and workable for characterizing exhaust emissions from motor vehicles. Warm-up characteristics of catalytic afterburners have been compared between operation in the prescribed driving cycle on the chassis dynamometer and operation in actual urban driving. The warm-up characteristics using the driving cycle fall near the center of the range of warm-up encountered in metropolitan driving. The driving cycle used is inadequate for evaluating emissions of devices which incorporate by-pass systems or flow modulating systems. - APCA 5136

835. Heinen, C.M.: Using the engine for exhaust control. Presented at the Los Angeles Section of the Society of Automotive Engineers Nov. 19, 1962.

The 1956 CRC Field Survey and the recent survey by the MVPCB both show wide variations in the carbon monoxide and hydrocarbon content of the exhaust of vehicles in the field.

There is strong evidence to show that the primary reason for these variations is engine condition.

For Chrysler cars now in the field, readjustment to and maintenance at factory specifications would result in values of about 500 ppm HC and 2.0 - 2.5% CO. This is an almost essential step for every type of additional control, whether it be by devices or engine modification.

Various engine modifications dealing primarily with the carburetor and distributor are possible on Chrysler vehicles which reduce the emissions to 275 ppm HC and 1.5% CO or below, and which have no substantial effect on performance.

With the possible exception of the idle adjustments (mixture and rpm) the normal factory recommended intervals should be adequate for maintaining vehicles at these levels. No special tools are required.

Maintenance of the type specified by the manufacturers for good vehicle operation should be strongly urged as an air pollution measure. No new garage equipment is required.

As soon as the present series of tests on engine modifications are completed, a production test on the modified engines discussed above will be justified unless some unexpected difficulty arises during the rest of the tests.

A production test of this type represents the final step prior to production and is conducted with the help of a substantial nummber of motorists. The object, of course, is to confirm that the experimental findings are verified by customer experience. - Author's Abst.

836. Henderson, Y., and Haggard, H.W.: Health hazard from automobile exhaust gas in city streets, garages and repair shops. The vertical exhaust as a practical measure of amelioration. J. AMA 81:385-391 (Aug. 4) 1923.

The air in city streets where there is considerable traffic is found to be contaminated with automobile exhaust gas to a degree in excess of proper and well established health standards. The amount of visible smoke is not an index of carbon monoxid content.

The conditions in garages and repair shops are, as a rule, extremely unhealthful. Many mechanics and drivers suffer almost daily partial asphyxiation with headache and other sequelae. Fatal asphyxiations in private garages are fairly common occurrences in the winter.

The conditions in the streets of American cities can be largely ameliorated by the use of the vertical exhaust on omnibuses, trucks, taxicabs, and private cars with tops. Cars without tops are now negligible in numbers in cities.

The horizontal exhaust now generally used mixes the gas throughout the respiratory zone of street air in a layer only about 10 feet deep. It thus dissipates the heat of the gas and prevents it from rising out of the street. The vertical exhaust, on the contrary, starts the hot gas upward with comparatively little admixture of air, and its heat carries it on up out of the street.

With the horizontal exhaust the entire air of the garage is rapidly mixed with exhaust gas. Adequate ventilation of garages is at present virtually not feasible. With the vertical exhaust, the heat of the gas holds it against the ceiling with comparatively little admixture of air, and the gas therefore readily finds its way out through any ventilator in the roof. - Authors' Conclusion

837. Hofreuter, D.: The automotive exhaust problem. Arch. Environ. Health 2:559-563 (May) 1961.

This paper considers the problems of automative exhaust products as they may effect the public health. Following topics are discussed: Conposition of automobile exhaust; possible irritating qualities of automotive exhaust gases; possible relationship of lung cancer to products of automotive exhaust, and certain specific substances of vehicular exhaust, namely carbon monoxide and lead. - AGC

838. Huber, E.W.: CO-formation in motor vehicle engines. Automobiltechnische Zeitschrift (ATZ) 62:320-325 (Dec.) 1960.

A study of whether and under what conditions the CO-formation of an engine can be reduced is discussed in this paper. Although the same CO-content is obtained with a good mixture with the same air ratio is as with a bad mixture, the fuel portion in the mixture and thus the CO-content can be reduced considerably with a good mixture. A partial-load operation is possible with a complete fuel consumption which reduces the CO-content to about one-tenth of that of the customary throttle control. By improving the mixing equipment and the course of combustion, the operating conditions, possible on the test stand, might also be realized in industry.

Tests with a compression-ignition engine with diesel fuel and with a gasoline operation in the case of excess of fuel, as well as with an NSU Wankel engine are reported. - Author's Abst. translated-AGC

839. Hurn, R.W.: Comprehensive analyses of automotive exhausts. Arch. Environ. Health 5:592-596 (Dec.) 1962.

Analytical methods, inert constituents of exhaust, and reactive and noxious constituents are discussed in detail. Experimental values for concentrations are shown in table 1. Values were related to composite samples for exhaust gases produced during appreciable intervals of time. Such values showing average emission during short periods or during simulated traffic cycles, are useful in estimating emissions to the atmosphere. Table 2 shows variations in stream composition during engine transients, fuel, and mid-continent area regular grade. - APCA 5007

840. Jackson, W.E.: Air Pollution from Automobiles in Philadelphia. Presented at the 58th APCA Annual Meeting, June 20-24, 1965, Toronto, Canada.

Trends in the increasing number of automobiles registered in the City of Philadelphia are analyzed and the data projected to 1975. Present air pollution emissions from automobiles are calculated and compared to total emissions from all sources. The estimated increased in automotive traffic is utilized to project total emissions from this source to 1975. Air sampling data are analyzed for correlation with traffic variations. Examples are given of pollution levels and smogs resulting from auto emissions. Emissions from automobiles having no control devices are compared with emissions from vehicles equipped with presently available control devices. Charts are presented which illustrate the annual decrease in emissions which would result from installation of such devices. The present activities of the Air Pollution Control Section regarding automotive emission control are discussed. Author's Abst.

841. Jensen, D.A., and Seanlin, J.R.: Methods of reducing pollution caused by internal combustion engine (motor vehicles.) Aspects Techniques de la Securite Routière. 19:1-24,29 (Sept.) 1964.

Methods for the control of pollution from internal combustion engines in California, are discussed in this paper. Devices have been developed to recirculate crankcase gases back into the engine and burn them. Catalytic mufflers and direct flame afterburners have been developed to oxidize hydrocarbons and carbon monoxide. There is a requirement that all diesel trucks and buses use high-grade fuel and to be well maintained to reduce air pollution respectively the smog problem. Four new exhaust systems have been approved by the California Motor Vehicle Pollution Control Board, which will have to be fitted to all vehicles beginning Jan. 1966. -AGC.

842. Jensen, D.A., and Grant, E.P.: Status of control of motor vehicle emissions in California. J. APCA 14:483-486 (Dec.) 1964.

In the State of California, because of an acute air pollution problem, it has been forced to move ahead on a pioneer basis to control motor vehicle emissions. There are different contaminants and emissions which require different methods of approach for control purposes which come from a single source. The program as put into operation by the Motor Vehicle Poll. Control Board is discussed. Recent developments in exhaust control, anticipated installation requirements, scheduling, and an indication of long-term planning is outlined. APCA 6420.

843. Kauper, E.K., and Hopper, C.J.: The utilization of optimum meteorological conditions for the reduction of Los Angeles automotive pollution. J. APCA 15:210-213 (May) 1965.

Advantage can be taken of optimum of conditions of turbulent mixing to decrease the intensity of automobile-caused pollution in the Los Angeles Basin. Changing the summertime peak traffic hours--delaying the morning rush by one hour--will result in an improvement of 24 percent for an eight-hour day, in terms of oxidant concentrations. Greater improvements (up to 54 percent) are possible by use of seven or six-hour days, should they be found to be economically feasible. - Authors' Abst.

844. Kaye, S.: Carbon monoxide poisoning. Virginia Med. Monthly 84:627, 1957.

This short one page paper relates the properties, general signs and symptoms, and treatment of carbon monoxide poisoning. Author also states that most common exposures are from exhaust of gasoline engines in enclosed spaces, and he relates that deaths have occurred by exposure in an open canopy cruiser at sea during a calm. The following toxic levels are given:

% Carboxyhemoglobin:
Below 5%--usually no symptoms.
Below 20%--mild symptoms.
Above 20%--moderate to severe symptoms.
Above 40%--may produce coma and death.

- AGC

845. Keeser, E., Froboese, V., Turnau, R., Gross, E., Kuss, E., Ritter, G., and Wilke, W.: Toxicology and Hygiene of Motor Traffic. Exhaust Gas and Benzine. Schr. Gesamt. Kraftfahrwesens, 1930.

This investigation was undertaken because of the increasing number of accidents due to inhalation of exhaust gases emitted by petrol-and benzol-driven motor vehicles.

Full details are given of: (1) the chemical analyses of the exhaust gases, the apparatus used (with illustrations) and the conduct of the experiments: (2) the toxicological experiments; and (3) the practical tests as to the amount of CO, CO_2, CH_4, etc., present in over 100 street blocks, tunnels, and large garages.

Naturally comparison is always made between conditions of the most perfect combustion and the most perfect action of the engine (at full load) and those much less satisfactory when the car is stationary with the engine running.

The general conclusion reached--in striking agreement with that arrived at in the Final Report of the English Ethyl Petrol Committee--is that carbon monoxide is the only gas with acute action given off. In consequence, however, of the extraordinary rapidity of dilution, the CO concentration in the atmosphere at breathing level rarely exceeds 2 parts per 10,000, so that risk to the general public is to all intents and purposes absent. In 95 of the 101 tests the proportion of CO was under 1.5 parts per 10,000. The highest was 2.7 which, it is said, closely corresponds with observations made by investigators in the United States. The highest proportion found by the Ethyl Petrol Committee was 1.7 parts per 10,000 (at Trafalgar Square) but, when taken, the sample bottle was quite close to the exhaust.

Inhalation of a proportion of 2 parts per 10,000 if continued for hours together must lead to some saturation of the blood by CO and symptoms of headache, and palpitation precautions are called for in the case of police on point duty in places where "hold-ups" are frequent, and in garages and repair workshops. - BMB 399

846. King, W.J., Wilson, K., and Swartz, D.J. Analysis of automotive exhaust gas. J. APCA 12:5-21 and 47 (Jan.) 1962.

This paper comprises a survey of the current state of the art in sampling and analyzing automotive exhaust gas with particular reference to those constitutents; chiefly hydrocarbons, carbon monoxide, and oxides of nitrogen, which cause objectionable air pollution. It is especially concerned with methods and instrumentation directly applicable to the measurement of such emissions from vehicles equipped with special devices or systems for complying with the Public Health Standards recently established as law in the State of California. -Authors' Introduction

847. Kling, A.: The principal factors in the pollution of town air. Rev. hyg. med. prev. 60:444-453, 1939.

Attention is also drawn to the atmospheric pollution caused by automobiles. Exhaust gases may contain as much as 10 percent of carbon monoxide. People living in ground-floor or first-floor apartments on busy thoroughfares are exposed to these fumes and suffer malaise when their windows are open, but are unaffected when their windows are kept closed. - BMB 400

848. Kobayashi, Y., Abe, T., Takeno, H., Kanno, S., Fukui, S., and Naito, S.: Investigation of the contribution of automotive exhausts to urban atmospheric pollution at a street of heavy traffic density in Yokohama. Japan Analyst (Tokyo) 12:1057-1062 (Nov.) 1963.

For the purpose of investigating the contribution of automotive exhausts to urban atmospheric pollution, measurements of contaminants in the atmosphere from these exhausts were carried out, during 1962-63, at 1 of the heavy traffic junctions of Takashima St., in the Nishi area, of Yokohama. As indicators of pollution levels from automotive exhausts, the concentrations of CO, CO_2, SO_2 NO, NO_2, and Pb in the atmospheric air were measured using detector tube and colorimetric methods. As the same time an estimation of traffic density was obtained, using a manual counter of all the cars and trucks passing a specified point for 10 minutes of each hour. The concentration of CO was in the range 1-40 ppm.; CO_2, 340-400 ppm.; SO_2, 0.2-11.3 pphm.; NO, 6-153 pphm.; NO_2, 1-64 pphm.; Pb, 1.4-41.4 µg./m.^{3} In general, the concentrations of these contaminants showed 2 maximum peaks, at about 9:00 A.M. and 5:00 P.M., and a minimum level at about 4:00 A.M. There was a high correlation between the concentration of air contaminants (CO, NO, NO_2), and the traffic density. - APCA 6313

849. Kopa, R.D.: Pneumatic Fuel Atomization as Applied to Automobile Air Pollution Control. Report No. 63-61. Depart. Eng., Univ. Calif., L. A., Dec. 1963, 16 pp. CFSTI - AD-601 025.

The test results presented in this report were obtained during the operation of an engine equipped alternatively with a factory standard carburetor or with a fuel atomization device. For the run with a conventional carburetor, the engine was tuned to factory standards and idling jets adjusted for the minimum of hydrocarbon emission. During the run with an atomization device the spark advance was usually close to factory standards; however, the air-fuel ratio was controlled by the atomization device in the range of the lowest hydrocarbon emission. Nitrogen oxides in the exhaust gas were determined by means of a nitrous fume analyzer calibrated by the phenoldisulfonic acid method. Unburned hydrocarbon content was measured by a nondispersive infrared analyzer as ppm. of hexane, and by a flame ionization detector as ppm. of total H-C bonds. Carbon monoxide content was measured by a nondispersive infrared analyzer. The high emissions resulting from engine operation with carburetors in condition "as is" are due to the fact that the standard carburetor is limited in its ability to maintain exactly the desired air-fuel ratio, since it is subject to wear and deterioration. Only a long-range road testing of the fuel atomization device will show how far it could be superior in this respect to a standard carburetor. Exhaust gas recycling devices developed earlier, and installed on engines equipped with standard carburetors, were limited in their ability to maintain exactly the desired air-fuel ratio, since they too are subject to wear and deterioration. - APCA 63-383

850. Labonde, J., Menetrier, M.L., and Pelletier, M.J.: Atmospheric pollution in the area of Paris and its effect on health. Pollution atmosphérique No. 28, pp. 530-565 (Oct.-Dec.) 1965.

One part of this report describes and discusses some instances of high carbon monoxide pollution arising from the conjunction of certain meteorologic factors and automobile traffic.

"Abnormal odors and a sensation of suffocation" were observed between 6 and 8 p.m. by passerby at the Place de l'Opera. Other evidence indicated that automobiles might be the cause of the evening CO pollution. The correlation between high pollution levels and physiologic observations inspired research into records accumulation by the Paris Hygiene Laboratory. A review of measurements made in the center of Paris during 1959-1964 disclosed that 91 times in 6 years, the level of CO passed 10 p.p.m. during an hour at least and that 44 (48%) of these episodes happened in September-October. 72 cases (79%) occurred in the early evening - about 6 p.m. - and 41 times (57%) in September-October. Very weak or stagnant wind conditions prevailed at the time of these episodes. Scheduled for 1966 is the installation of equipment whereby simultaneous measurements will be made of CO levels at different heights in a narrow street and of the heavy Parisian traffic. - From French-CBK

851. Larsen, R.I.: Air pollution from motor vehicles. Presented at the Meeting of the New York Academy of Sciences, April 6, 1966.

Motor vehicles are a major source of urban air pollution. They emit carbon monoxide that reduces man's ability to transport oxygen to his tissues; lead that increases man's body burden of this toxic metal; cancerigenic hydrocarbons; and reactive hydrocarbons and nitrogen oxides that combine with sunlight to produce eye-irritating, plant-damaging, visibility-obscuring photochemical smog in New York as well as in California

Present and predicted air pollutant concentrations are compared with pollutant effects and air quality standards. Emission-reduction features presently used in new cars sold in California will improve air quality, but will not completely solve the problem. Indications are that 95 percent reduction in emissions of carbon monoxide, hydrocarbons, and nitrogen oxides from new cars sold in the united States may be needed by 1975. Such a "clean-air car" by 1975 is suggested as a research goal for automobile manufacturers. At present, improved fuel cells or improved battery power seem to be the most likely means for achieving this goal. - Author's Abst.

852. Lawther, P.S.: The clinical significance of dirty air. Proc. Conf. National Smoke Abatement Soc., Oct. 1956.

Driving through London for 3 hours with the windows shut and the air intake on, investigator reported carbon monoxide concentrations of 130 ppm in the vehicle, the passengers' carboxyhemoglobin doubling over their previous control values. Although these levels were not harmful to the healthy passengers, author is unable to state, as yet, that they would not be of any significance to ill persons. This work is continuing. - AGC

853. Lawther, P.J.: Air pollution and the public health. From a lecture to the Royal Society of Arts. Smokeless Air, Summer 1965, pp. 285-288.

The following is quoted from a brief review on the problem of motor vehicle exhaust, presented in this lecture:

> "But petrol engines, unlike the properly run diesel, emit carbon monoxide and this is the only pollutant which we have found in city air in concentrations which would not be tolerated in industry. On the pavement in Oxford Circus we once found three and a half times the acceptable Maximum Allowable Industrial Concentration. Carbon monoxide is an odourless asphyxiant gas about which much is known. It is commonly used, in coal gas and from a car, to commit suicide. The haemoglobin of the blood seizes it avidly in preference to oxygen and there is a growing body of evidence that even low concentrations in the blood, insufficient to cause symptoms, can lead to impaired judgement.

854. Lies, K.H.: Methods and devices for the analysis of exhaust gas caused by internal-combustion engines. Tech. Uberwach. (Essen.) 4:322-325 (Sept.) 1963.

Automatic physical-chemical, or purely physical, methods for the analysis of motor exhaust gases are superior to conventional manual analysis. With automatic methods results are continuously available; they are more exact and reproducible without any waste of time. The extraction facility is usually the same, only the methods are different. Photographs, and some working diagrams, are used to illustrate the discussions on dispersive and non-dispersive infrared analysis, flame ionization, gas chromatography, and magnetic analysis. - APCA 6630

855. Löhner, K., Müller, H., Luther, H., and Ihrig, H.: Carbon monoxide content of the exhaust gases of automobile combustion engines. Automobiltechnische Zeitschrift (ATZ) 62:311-320 (Dec.) 1960.

After a description of the testing installation of a continuous CO analysis on the basis of infrared absorption, the results of tests with regard to CO content in the exhaust of a diesel engine for motor vehicles and of four Otto engines are given. In addition to data from stationary tests of characteristics, the study reports on the behavior at accelleration and decelleration, and at long-distance travel during a driving test. The scattering ranges of the test data and the related variation of the CO emission of a normal engine are given. - Authors' Abst. translated-AGC

856. Ludwig, J.H.: Present status of vehicle exhaust in air pollution. Sanitarian's J. Environ. Health 25:20-25, and 29 (July-Aug.) 1962.

A review of the various types of motor vehicles in use today, and associated power plants, indicates that as a group the spark-ignited gasoline-powered passenger car accounts for the major share of automobile exhaust emissions associated with production of photochemical smog. Satisfactory devices for the control of crankcase ventilation in gasoline-powered vehicles are not available, and "life testing" is proceeding on exhaust devices for gasoline-powered vehicles. The major problems associated with diesel exhaust stem from production of smoke and odors. The former may be reduced considerably by proper engine design, maintenance and driving habits; entirely satisfactory control of the latter requires increased research and development relative to the nature of the compounds involved, and engine modifications or equipment required to eliminate them. APCA 6543

857. Luther, H.: Research problem: Exhaust gas. ATZ (Automobiltechnische Zeitung) 62:326-328 (Dec.) 1960.

This article is a survey of the status of research and development in the abatement of injurious pollutants from the exhaust gas of internal combustion engines. Several research groups in Germany, currently engaged in this endeavor, are cited. Chemical modification of exhaust gas composition (e.g. carbon monoxide), physiological effect of exhaust gases and testing of proposed methods of the modification of engine exhaust gases are reviewed. - AGC

858. Luther, H.: The measurement of automobile emissions. STAUB 21:125-131 (Feb.) 1961.

The determination of the composition of motor vehicle exhaust gases is of interest in identifying the troublesome and injurious substances. Therefore, a survey is 1st presented covering analytical procedures employed and the methods of sampling. Then follows the description of some measuring arrangements, infrared spectroscopy, gas chromatography, etc., with which the most important components of exhaust gas can be continuously measured. Finally, some results of exhaust gas measurements are given as examples of the application of the process described. - APCA 4071

859. Lykova, A.S.: The role of motor vehicle exhaust gases in contaminating the atmosphere of large cities. Trudy Leningrad. Sanit.-Gigien. Med. Inst. 14:89-102, 1953.

The CO content of air samples taken from various locations in large Soviet cities, i.e., on and near highways, in residential areas and in industrial area remote from major highways, at various times of day is correlated with density of adjacent automobile traffic. Samples taken in pedestrian breathing zones had CO content (mg./m.^{3}) ranging from 4 to 164 (0.003 to 0.1312 ppm), averaged ca. 6 with fewer than 1000 cars/hr., 13 at 1000-1500 cars/hr., 25 at 1500-3000 cars/hr. and reached maximum values at service stations. CO concentration in residential areas having motor transport was greater than in industrial areas without motorized transport. CO was more frequently detected and concentrations were higher in the winter. The "average" CO content of Soviet cities (17.8 mg./m.^{3}) is much less than corresponding values ascribed to certain other cities (75 for Chicago and 126 for Paris in 1938, 100-318 for the U.S.A. in 1925-28). Traffic control personnel show higher blood CO hemoglobin content (as compared with people not exposed to air containing continual low-level CO) sufficient to account for general complaints of headaches and dizziness as being due to chronic CO intoxication. Erythrocyte count, hemoglobin content and O_2-capacity data are included for the test personnel. - Kett.

860. McCormick, R.A., and Xintaras, C.: Variation of carbon monoxide concentrations as related to sampling interval, traffic and meteorological factors. J. Appl. Meteorol. 1:237-243 (June) 1962.

Diurnal variations of carbon monoxide concentrations and traffic density, exemplified in the literature as common for urban areas, were observed at "curb-side" studies in Nashville, Tennessee, and Cincinnati, Ohio.

A new technique is suggested for evaluating the effect of changes in traffic density on CO concentrations which may be useful for urban planning purposes and for appreciating the role wind speed can play to modify these assessments.

Peak to mean ratios of CO concentrations at Cincinnati were in the same range, 2:1-3:1, as those reported in single-source experiments in open terrain in which the source and receptor were located at the same height. In both cities, the decrease of the average ratios, Xr/X60, (maximum short-period CO concentrations within the hour to the mean value over the hour) with increasing r, proceeds at a somewhat slower rate for $r > 3$ min than in single source cases. Multiple and indefinite sources of CO in the immediate area of the urban sampling sites undoubtedly account for this by providing an atmosphere which is never entirely free of CO contamination. - Authors' Abst.

861. McFarland, R.A.: Human factors in air transportation. McGraw-Hill, New York, 1953, pp. 301-303.

R.J. Goldsmith and L.H. Rogers are quoted to the effect that "The importance to automobile drivers of visual sensitivity at night is obvious. However, it has not been shown that exposure to automobile exhaust at the levels found on the freeways of a modern city impairs the adaptability of eyes to darkness or alters the exchange of vital respiratory gases, although this is a plausible inference." -

862. McFarland, R.A. and Moore, R.C.: Human factors in highway safety. A Review and Evaluation. New England J. Med. 256:890-897 (May 9), 1957.

This article is the last of a series of three papers appearing in previous issues dealing with the same subject. The interrelationship between "lost" and "environmental" factors are the last subject discussed.

Author states that the possibility of CO poisoning can rarely be completely eliminated in the operation of motor vehicles. Although significant concentration of CO in motor vehicles usually is the result from leaks in the exhaust system, gas from the exhaust of preceding vehicles may also be drawn in through ventilation systems. The paper points out that exposure to 0.10 percent CO can be dangerous to life after one hour. Exposure to even as small a concentration as 0.01 percent should not be permitted over a long period. CO from other sources may be detrimental to the driver. The blood of a person who has been smoking heavily may already contain 5 to 8 percent carboxyhemoglobin from the CO inhaled in the tobacco smoke. This amount results in sufficient anoxia to reduce night vision significantly, comparable to the effects of high altitude of about 800 feet.

This factor is illustrated by a graph. In conclusion , author states that the physician, in collaboration with other biologic scientists and engineers, will play an important part in the prevention of accidental trauma. -AGC.

863. MacKenzie, V.G.: The role of the scientist and the citizen. A case study: air pollution. U.S. DHEW, PHS, Div. of Air Pollution, 1965, 5 pp.

In examining one important group of pollution sources, namely from fuel combustion, author sees the following developments by the year 2000 in regard to carbon monoxide:

> Estimated emission will rise to about 465 tons, almost four times the 1960 figure.

This figure reflects the growing importance of pollutant discharges from internal combustion engines, particularly in automobiles. It also indicates the desirability to pursue the present efforts to reduce emissions from spark-ignition gasoline fueled engines and to examine the feasibility of developing vehicular motive power having less inherent pollution potential. - AGC

864. McMichael, W.F., Smith, R., and Kruse, R.E.: Comparison of auto exhaust emissions from two major cities. Presented at the 57th APCA Annual Meeting, June 21-25, 1964, Houston, Texas

Exhaust emissions from automobiles in a low-altitude city will be compared with emissions from autos in a high-altitude city (Denver, Colorado). The comparison will be based on samples collected from thirty five cars driven under actual road conditions in each city.

Results will be discussed on the basis of CO, CC_2 and hydrocarbon concentrations versus average route speeds and on pounds of CO, CO_2 and hydrocarbons, emitted per mile, versus average route speed. - Authors' Abstract

865. McMichael, W.F., and Rose, A.H., Jr.: A comparison of automotive emissions in cities at low and high altitudes. Presented at APCA Annual Meeting, Toronto, Canada, June 1965.

The U. S. Public Health Service, continuing its investigations of automobile exhaust emissions in large cities, conducted a study in Denver, Colorado, in cooperation with the Colorado State Department of Public Health. This study was of particular interest to the Public Health Service because Denver is unique among large cities in the United States in that it is situated at an altitude of approximately 5,000 feet; this study thus provided the opportunity for observing the effects of altitude on auto exhaust emissions.

This report compares the emissions measured in Denver in 1963, with the emissions obtained in a similar, previously reported study in Los Angeles, California, and Cincinnati, Ohio.

The survey techniques and the instrumentation used to collect and analyze the exhaust samples in Denver were the same as those used in Los Angeles and Cincinnati and are therefore described only briefly. Emission measurements were made on test vehicles driven under actual traffic conditions while equipped with a proportional sampler. This method produces data that reflect the effects of traffic density, route, climate, and altitude. - Authors' Introduction

866. Matthes, B.: Air pollution by motor vehicles. Tech. Uberwach. (Essen) 2:415-420 (Nov.) 1961.

Special sampling and analysis procedures are required in studying motor vehicles as sources of atmospheric pollution. Following a survey of the composition of exhaust gases and the usual concentrations of the most important components, present methods for a reduction of undesirable substances in the gases--which are known and can be tested--are discussed. In Germany the 1st efforts have been concentrated on the elimination of smoke development by diesel vehicles, and on decreasing the amount of CO in the exhaust gas of Otto engines. APCA 6632

867. Methods of Reducing Pollution Caused by Internal Combustion Engines (Motor Vehicles). (General Report.) European Conference on Air Pollution, June 24-July 1, 1964. Council of Europe, Strasbourg (France), 1964, 40 pp.

This General Report, published following the European Conference on Air Pollution, is presented by Prof. Brunner, Federal Institute of Technology, Zurich, and Laboratoire fédéral d'essai des Matériaux, Switzerland; and Mr. Lemaigre, Président de l'Union Technique de l'Automobile, du Cycle et du Motorcycle, Paris. The table of contents lists: Introduction; Organization of action to combat pollution from motor vehicles; Studies and research: organization and results; Ways and means of reducing pollution; Anti-pollution legislation. Appendix I (13 pages) is entitled Public and private European bodies concerned with air pollution; Appendix II (26 pages), Bibliography; Appendix III (8 pages), Legislation. - APCA 64-267

868. Milokostova, L.G., and Prokopenko, K.A.: Rostov-on-Don atmospheric air pollution with auto-traffic exhaust carbon monoxide 1960. In: Levine, B.S. (editor and translator): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. Vol. 8, 1963, pp. 215-217, CFSTI-TT-63-11570, U.S. Dept. of Commerce, Springfield, Va.

Air pollution by motor vehicles was investigated at five points on four major roads in Rostov-on-Don. This city has heavy traffic and is also an important junction. An average of 600 cars and a maximum of 800 cars per hour were observed at point one. At point three there were 700 resp. 1000 cars per hour and at the fourth point there were 500 resp. 900 cars. Point Nos. 2 and 5 were located at narrow roads, one was a one way street. An average of 250 and a maximum of 450 cars were passing point 2. Four hundred and sixty-seven respectively 700 cars passed hourly at point 5. Sampling was done in April through September from 8:00 a.m. to 7:00 p.m. A total of 1280 samples were analysed. - AGC

868a. Morando, A.E., and Rovida, S.: On the exposure of a sample of the population policemen, to atmospheric carbon monoxide deriving from motorized traffic. Giorn. Igiene Med. Prevent. (Genoa) 6:78-90 (Jan.-March) 1965.

The authors carried out this survey among a number of traffic policemen on duty at different street intersections in Genoa, as a sampling of a population particularly exposed to the absorption of carbon monoxide. No indication of variation in the levels of carboxyhemoglobin in the blood was found. The policemen were examined before and after their periods of duty. On the other hand, it was once more confirmed that the smoking habit plays a remarkable role in the study of levels of carboxyhemoglobinemia. - APCA 7255

869. Moureu, H.: The various aspects of pollution by the exhaust gases of motors of internal combustion. Rev. Pathol. Gen. Physiol. Clin. (Paris) 61:915-931 (July) 1961.

Although automotive traffic has not reached the density in Paris that it has in Los Angeles, it is increasing rapidly. Concern for this type of pollution, especially that from ozone and carbon monoxide, was felt for the drivers of automobiles and for pedestrians involved in heavy traffic. A chart in the text compares carboxyhemoglobin (HbCO) levels of a group (303 persons) of automobile drivers, another group of professional personnel (867 persons) exposed to CO, and another of controls (435 persons). In a range of blood levels of 0.2 to 2.5 ml./100 ml. of blood, a greater number of drivers had levels in the higher half of this range. At a level marked in the table as "serious" (1.2 ml./100 ml.), nearly 40% of the drivers, less than 25% of the workers, and only about 7% of the controls were higher. The technical solution of the control of exhaust gases has probably now been solved by American manufacturers with equipment, developed past the laboratory stage, which will not be prohibitive in cost. The controversies over the use of diesel motors have also become resolved with the decision being that well-run and well-maintained diesel motors produce little exhaust. The international colloquium on atmospheric pollution, which was held in Royaumont in April 1960, included among its recommendations the dieselization of public transport. It has been established that the level of CO pollution in the public gardens is 5 times less than on busy streets. Wide avenues and areas of greenery are imperative in control of this type of air pollution. Again the running conditions of the motor are so important in controlling the degree of pollution that they should be under official supervision and inspection. In large cities, especially, the running of motors at an idling level should be reduced to a minimum. - APCA 4635

870. Moureu, H.: Carbon monoxide as a test for air pollution in Paris due to motor-vehicle traffic. Proc. Royal Soc. Med. 57(Part II): 1015-1020 (Oct.) 1964.

Among the various forms of air pollution that due to motor-vehicle traffic shows the greatest complexity because of the numerous chemical substances involved. The various aspects of air pollution by motor-vehicles, especially that from carbon monoxide, are discussed as to the level of such pollution, degree of pollution related to intensity of traffic, and relation of such pollution to the level in the blood. The author concludes by saying that the use of carbon monoxide levels as an indicator of motor-vehicle pollution may not necessarily be applicable elsewhere. It is quite certain, for instance, that in some towns in the U.S.A., such as Los Angeles, it is the concentration of oxidant in the air which constitutes the principal factor characterizing the degree of pollution; carbon monoxide in such cases may be of only secondary importance. Since pollution by motor-vehicle traffic shows a tendency to increase in Paris in comparison with the general pollution, studies have also been carried on to identify by other criteria the pollution due to exhaust gases. Special attention is being paid to concentration of nitrogen oxides which, being emitted at high temperature by combustion processes, may play an essential part in the initiation of photochemical reactions leading to the 'oxidant' form of air pollution. APCA 64-259

871. Payne, J. Q., and Sigworth, H.W.: The composition and nature of blowby and exhaust gases from passenger car engines. Proceedings of the 2nd National Air Pollution Symposium, pp. 62-70, (May 5-6) 1952, Pasadena, Calif.

Blowby and exhaust rates increase with increasing power output. Engine mechanical condition has little effect on exhaust rates, but poor mechanical condition can cause a greater than tenfold increase in the rate of blowby under some conditions. Materials such as CO, CO_2, H_2O, H_2, O_2, and N_2 were found to comprise over 99 percent of the composition of both exhaust and blowby. The remaining less than one percent contains the noxious materials. Except under decelerating conditions, exhaust gases contain a lower proportion of noxious products than blowby gases and no materials of mass greater than 58. Common conditions of engine malfunctioning such as misfiring and retarded timing can increase the concentration of noxious products in the exhaust. The concentration of noxious products in blowby was affected by fuel type, carburetor adjustment, and power output. The following classes of compounds were identified as present or probably present in blowby: Paraffins, olefins, aromatics, cyclics, acids, alcohols, aldehydes, and an organic hydroperoxide. No material of mass number higher than 86 was found in greater than trace quantities. Graphs and tables supplement the text. -Authors' Sum.

872. Portheine, F.: Pollution of air in the streets by exhaust gases of motor vehicles. Therapiewoche (Karlsruhe) 9:348-355 (April) 1959.

The various orographical and topographical parameters which have an unfavorable effect on the mass-exchange of the exhaust gases of motor vehicles, are pointed out. In 1957, 3455 million tons of petrol and 3419 million tons of diesel oil were burned to provide power for over 8 million motor vehicles. The problem of exhaust gases is definitely not a problem of carbon monoxide, since in homogenous masses of air under unfavorable conditions only 1/3 to 1/4 of MAC value of CO were demonstrated at points where the traffic was thickest. Attention must be paid to effects of combined poisons and enzymatic damage. Studies on the amount of lead in samples of grass from the highways yielded values that must be checked further and compared with similar studies in other countries. The values ranged from 15000 µg. of lead/100 g. of grass at the start of the vegetational period to 100,000 µg. of lead/g. of older grass. Lead is an enzyme poison. - APCA 3359

873. Primavesi, C.A.: Motor vehicle exhaust and its significance to human health. Zeitschrift Präventive Medizine 9:148-159 (May-June) 1964.

The author who is associated with the Hygienic Inst. in Gelsenkirchen, located in the heart of the Ruhr Valley, which is about the most polluted area of the European continent, emphasizes the effect of motor vehicle exhaust on human health. He discusses primarily the emission of CO, lead compound and carcinogenic agents. Methods for the determination of pollutants from motor vehicles and their control are discussed. - AGC

874. Regan, C. J.: Motor fumes and atmospheric pollution. Chem. & Indust. 51:605 (July) 1932.

The author feels that too little attention is given to the pollution of the air by motor exhaust fumes. Estimates are given of gallons of fuel used for the years 1911, 1921, 1931, showing the marked increase. Carbon monoxide is regarded as the most important constituent contaminating the air. It is released as 6.5 percent of the total exhaust gas, with 72.8 cubic feet produced per hour with a car running at 20 miles per hour. Reporting on various investigators' determinations of carbon monoxide in cities, which varied from 3.4 to 17 parts per 100,000, Keeser, Froboese and Turman wrote that in their investigation the concentrations rarely got above 20 parts per 100,000 and hence there is "no danger to acute carbon monoxide poisoning of ordinary street users." Traffic police are considered to be in a more hazardous position with as much as 30 percent carbon saturation of hemoglobin being reported at the end of tours of duty of traffic police. These same authors found that exhaust condensates cause lung injury in mice, but it is not believed these products would exist in a high enough concentration in the street to cause injury. - BAAP 298

875. Renzetti, N.A.: Analysis of Air Near Heavy Traffic Arteries. Air Poll. Foundation Rep. No. 16, Dec.1956, Los Angeles, Calif.

The range of concentration of the principal constituents of automobile exhaust in the vicinity of heavy traffic are discussed in this report. Six stations were selected on the basis of heavy traffic. At these stations, samples were taken at essentially ground level within 60 to 75 feet of the traffic artery, from 6 AM to 9 PM on week days of the period from September 6 to October 2, 1956. This period was characterized by low inversions, low winds, and high solar radiation, and on a number of these days high oxidant values and eye irritation were experienced. The samples were analyzed for carbon monoxide, hydrocarbons, and carbon dioxide by infrared spectrometry. The carbon monoxide values ranged from 4 to 93 ppm; the hydrocarbons (as hexane), 0.25 to 2.3 ppm; and carbon dioxide from 0.05 to 0.14% by volume. Sampling technique, and methods of analysis are described, and results are tabulated. Other tables show average carbon monoxide concentrations, severity of eye irritation, and maximum oxidant concentrations at the monitoring stations of the Air Pollution Control Department during the period of the tests.

875a. Rispler, L., and Ross, C.R.: Ventilation for engine exhaust gases. Occupat. Health Rev. 17:19-22, 1965.

The composition and discharge rate of engine exhaust vary considerably, as they are dependent upon the fuel used, size and type of engine, operating speed, and maintenance. A comparison is made of the actual amounts in which the components are emitted from engines. The difference in ventilation requirements for diesel and gasoline engines, exhaust gas, emissions, and the toxic effects of carbon monoxide and nitrogen oxide are discussed. - APCA 7233

876. Rose, A.H.,Jr., Stahman, R.C., and Stevenson, H.J.R.: Exhaust Contamination in Passenger Cars. RATSEC TR A61-2, USPHS, Div. Air Poll., Cincinnati, Ohio, Feb. 1961.

A small number of tests run were made within a preliminary test program to investigate some basic factors effecting the concentration of exhaust gas induced into the passenger compartment of an automobile by the forced ventilation system. To stimulate heavy traffic conditions tests were run on grouped moving and grouped stationary vehicles. Exhaust concentrations in the passenger compartment of vehicles under moving traffic conditions were slightly above the background curbside levels. Stationary traffic conditions with vehicles grouped at average intervals produce marked increase in exhaust concentrations with the highest recorded at 0.8% [370 ppm carbon monoxide (CO)] of the raw exhaust value. In moving vehicles, the highest value recorded was 0.04% (20 ppm CO) above the curbside level.

The location of the forced ventilator inlet was shown to exert a significant effect on the exhaust concentration in the vehicle passenger compartment. Front inlets as contrasted to cowl and side inlets consistently gave higher values. Stability and movement of the air mass circulating around the stationary vehicles was the second factor exerting a significant influence on passenger compartment concentration. No significant effect was indicated by the differences in exhaust tailpipe location as used in present day automobiles. A vertical exhaust system (extended to car top level) gave essentially zero passenger compartment concentration. - Author's Sum. Modified.

877. Rose, A.H., Jr., and Smith, R.: A direct measurement technique for automobile exhaust. Arch. Environ. Health 5:609-615 (Dec.) 1962.

The latest survey of photochemical air pollution indicates that this condition occurs in most of the major cities in 19 states, Ontario, Canada, and the northern regions of Baja California, Mexico. In 1961 studies were made of exhaust emission based on direct measurement of emissions from operating vehicles. Direct measurement, a new technique in large-scale studies should provide necessary data on exhaust emissions during vehicle operation. Data indicate that acceleration contributes the largest portion of pollutants/average mile traveled. Cruise and deceleration contribute significant amounts with relatively minor amounts resulting from idle time. When sufficient tests have been made to establish the statistical soundness of the data, automotive exhaust emissions under actual driving conditions will be analyzed, and estimates of total emissions in urban areas will be provided. - APCA 5015

878. Rose, A.H., Jr., Smith, R., McMichael, W.F., and Kruse, R.E.: Comparison of auto exhaust emissions in two major cities. J. APCA 15:362-366 (Aug.) 1965.

Exhaust emissions from automobiles in a low-altitude city will be compared with emissions from autos in a high-altitude city (Denver, Colorado). The comparison will be based on samples collected from thirty-five cars driven under actual road conditions in each city. Results will be discussed on the basis of CO, CO_2 and hydrocarbon concentrations versus average route speeds and on pounds of CO, CO_2 and hydrocarbons, emitted per mile, versus average route speed. - Authors' Abst.

879. Schlipköter, H.W.: Effects of air pollution on man. In: Lufthygiene in Dortmund. Vortragstagung 20. Nov., 1964. Gesellschaft für Technik und Wirtschaft E.V., Dortmund, Germany, March, 1965, pp. 26-34.

The toxic effects of varying concentrations of NO_2, CO, SO_2, H_2SO_4 and 3,4-benzopyrene in air are discussed. Tables are given showing the types of particles, inorganic gases, and organic vapors produced by various industries and by the burning of fuels. The physical symptoms caused by varying the concentration of NO_2 in the air are described from observations made on laboratory mice and on men. Similar graphical evaluations are given listing the physiological reactions of man and various experimental animals observed at varying concentrations of CO and SO_2 in the air. The measurement of the dust content in the air is felt to be instrumental in causing psychological depression, allergic reactions, and broncho-constrictive irritation. The amount of daylight reduction by dust in the winter in English industrial towns is estimated to range from 25 to 55% of normal. The percentage of reduction in the Rhine and Ruhr areas can be as great as 50%. The author shows that concentrations of sulfuric acid and 3,4-benzopyrene appear in the air which can prove harmful to the health. It is suggested that basic research be carried out on other air pollution components and the combined effect of two or more such components. - APCA 65-162

880. Serruys, M.: Noxious materials in exhaust gases of automobiles. Chimie et Industrie 82:663-675 (Nov.) 1959.

The author studies the nature and importance of atmospheric pollution particularly by exhaust gases from combustion engines and Diesel engines, under all "working conditions".

He then deals with methods used for reducing the amount of unburnt gases and comes to the conclusion that the use of a device (such as the "M.S." regulator for example) which improves the conditions of combustion inside the motor is preferable to any other solution. - Author's Abst.

881. Smith, A.M., and Struck, J.H.: A simplified method for characterizing a motor vehicle's exhaust emissions. J. APCA 11:251-253 and 258 (May) 1961

An absolute technique has been developed for characterizing the exhaust emissions of an automobile as operated through a complete traffic cycle. The technique involves the collection of all of the exhaust gases in an evacuated plastic bag. Subsequent measurements of the composition and volume of this total sample can be accomplished using any available laboratory measuring technique.

Plastic bags of Mylar film were shown to result in no change in hydrocarbon, carbon monoxide, or carbon dioxide concentrations for one hour after bag filling. Plastic bags made of polyethylene are considered usable if measurements are made immediately after filling the bag.

The inherent accuracy, utility, and simplicity of this technique will eliminate many of the current measurement problems now plaguing those involved in evaluating automobile exhaust emissions. - Authors' Sum.

882. Stahman, R.C., and Rose, A.H., Jr.: Emissions from carbureted and timed port fuel injected engines. J. APCA 16:15-18 (Jan.) 1966.

A comparison was made between the exhaust emission characteristics of a popular make car when equipped with the stock carburetor and when equipped with a timed-port fuel injection system. A brief optimization study was made to adjust the spark timing and fuel flow characteristics to minimize emissions. Performance and economy were compared between the fuel injected and carbureted versions. Emission measurements of CO, CO_2 and hydrocarbon were made in road tests by proportional sampling and through the California Cycle by continuous nondispersive infrared instrumentation. - Authors' Abst.

883. Stephens, E.R., Hanst, P.L., Doerr, R.C., and Scott, W.E.: Auto exhaust: Composition and photolysis products. J. APCA 8:333-335 (Feb.) 1959.

This paper describes some simple analyses of engine exhaust using a long-path infrared absorption cell. Some of these samples, diluted with oxygen, were irradiated with a mercury vapor lamp which simulates sunlight. The products of the photochemical reactions were determined and are also reported. This was done to provide information on the products to be expected when the exhaust is vented to the atmosphere and allowed to react under the influence of sunlight. Samples were taken on the road. When the accelerating, decelerating, and idling samples were taken the mileage was 2000 and it was burning a mixture of 2 regular gasolines. When the cruising sample was taken several months later the car had a mileage of 3500 and was burning another regular gasoline. The exhaust gases were sampled directly; they were not passed through any drying agents or other absorbents. Several points should be noted concerning the method of sampling used. Since no drying agents are used and the sample is expanded into the cell the chances of losing any components of the exhaust are minimized. Since 5 l. of exhaust were expanded into a cell of 500 l. vol. the dilution was 100-fold. Similar results could have been obtained by sampling directly into a 1-meter cell. - APCA 2347

884. Stern, A.C.: How the United States looks at the auto exhaust problem. Presented at the Air Pollution Congress of the Swedish National Clean Air Council, Stockholm, Sweden, May 5, 1965, USDHEW, PHS Div. of Air Pollution, Washington, D. C.. 1965, 31 pp.

The problem of auto exhaust is discussed in this paper under various subject headings: photochemical smog and its effect; air quality standards and criteria; pollutant levels in the air of the U.S. and vehicular emissions. Recent experiences with blow-by systems and developments affecting afterburners, as well as engine modifications and new-type engines are discussed. In the section Pollution Inside Passenger Compartment, author states that in 1961 it was found in a series of tests that CO concentration in the passenger compartment under moving traffic conditions was slightly above the background curbside level, reaching a maximum value of 20 ppm above curbside level. Stationary traffic conditions with vehicles close together produced as high as 370 ppm of CO in the passenger compartment. High CO values are frequently recorded in the driver's seat in California freeway and street driving. There is also a bibliography of 20 references and 22 pages of added information. tables, graphs, and photographic reproductions. - AGC

885. Teague, M.C.: The determination of carbon monoxide in air contaminated with motor exhaust gas. J. Indust. & Eng. Chem. 12:964-968 (Oct.) 1920.

The iodine pentoxide method for determining low concentrations of carbon monoxide has been investigated with reference to its use with dilute motor exhaust gas. The type of apparatus heretofore used was found to give appreciably high results owing to the presence of small amounts of unburned gasoline. A new iodine pentoxide apparatus (Type II) has therefore been developed. All of the interfering gases are first removed at the temperature of liquid air. This method has been found quite satisfactory for determining carbon monoxide in small quantities in the presence of gasoline vapor.

A portable iodine pentoxide apparatus has been designed which should permit a determination to be made in 15 minutes with an accuracy of from 0.003 to 0.005 per cent carbon monoxide (0.3 to 0.5 part in 10,000). - Author's Sum.

885a. Thiebault, R.: An interesting experiment, made with the vehicles of the Parisian Préfecture de Police, in order to reduce the rate of carbon monoxide emitted by petrol engines. Centre international de documentation sur l'inspection et la technique des vehicules automobiles. (CIDITTIVA Bulletin) Brussels, No.23, pp. 2.1-2.11 (Sept.) 1965

Since 1959, the Municipal Laboratories of the Prefecture de Police have been systematically measuring atmospheric pollution in Paris, deducing the general picture from the carbon monoxide (CO) percentage. The many recordings made have led to three main conclusions: (a) Practically no CO during night hours, when motor traffic is sparse. (b) Definite correlation between density of traffic flow and CO rate. (c) Increase of each vehicle's contribution to the CO rate as traffic becomes less fluid, causing vehicles to stop frequently with motor idling. This, together with the fact that idling represents 75% of the time spent on a journey in heavy rush hour traffic, led to the idea of adjusting the relevant arrangements of the carburetor in order to reduce exhaust toxicity to a minimum, without hampering the engine. The method for adjusting the idling and slow running arrangements of the carburetor is described and results obtained are shown in a table. This method was successfully applied to all 1300 police vehicles and brought about the additional advantage of a considerable air pollution abatement in the police garages. Author suggests an education campaign for mechanics and maintenance personnel and wide information of the public on this subject and method. - APCA 65-167

886. Wilkins, E.T.: Exhaust gases from motor vehicles. (b) Some measurements of carbon monoxide in the air of London. Royal Soc. Promotion of Health Journal 76:677-684 (Oct.) 1956.

Carbon monoxide was determined by means of tubes containing silica gel impregnated with potassium pallado-sulfite which gives an accuracy of ± 20% at 50 ppm. Samples were collected between 9 A.M. and 5 P.M. on one day in each month from February through December (except October and November) 1955 at nine busy street intersections in central London and one near the center of Hyde Park. The concentrations found at the former locations varied between 1 and 50 ppm with an average of 15 ppm; those found in Hyde Park were consistently below 1 ppm. Tables are given relating carbon monoxide concentrations to traffic density, the rate varying from 20 or less to 54 vehicles per minute. Data on the effect of height above ground level showed a steady decrease with increasing height, the concentration at 100 feet being about one-third that at ground level. Concentrations during days of smog in January 1956 showed maximum of 10 to 50 ppm with averages for corresponding days of 4 to 14 ppm. Similar data for other English cities during days of smog in January 1956 are included, the only area where the London values are exceeded being in Salford with maxima of 16 and 80 ppm and corresponding averages of 9 and 20 ppm.
APCA 1269

887. Wolfson, Z.G.: Atmospheric pollution by motor exhaust gases. Gigiena i Sanitaria, pp. 46-53, 1948.

The composition of exhaust gases and their toxicity depend on a number of variable factors, but CO is the principal deleterious constituent that occurs in toxic concentrations; others (unsaturated hydrocarbons, aldehydes) are present in too small proportions to affect health. With increasing motor traffic, the toxic concentration of CO may spread beyond the line of traffic to the vicinity of main roads. Indirect effects also have to be considered, for example, absorption of UV rays and sunlight, disagreeable odor that favors superficial breathing, etc. The remedy lies in (1) insuring the most complete combustion possible by proper engine design, adjustment of carburators to poor mixtures with frequent inspections and overhauls, especially of nozzles, use of high-grade fuel with frequent quality and purity tests; (2) care in avoiding fuel and exhaust leaks, smoke due to oil splashes, insuring proper compression, fitting tractors, buses and trucks with gas absorbers and ejectors having outlets at 6 to 8 feet above ground level; and (3) regulations to concentrate main flow of traffic over wide roads with pedestrian traffic at a safe distance, keeping traffic, garages, etc., away from narrow streets and congested districts, suitable official control to insure observance of all these points. - BMB 403

Tunnels

888. Ash, S.H., and Naus,L.L.: Use of diesel engines in tunnels. Bureau of Mines Info. Cir. No. 7222, 1942, 26 pp.

In diesel-engine operations when the exhaust gases contain carbon monoxide in the amount of 0.01 percent and carbon dioxide to 0.3 percent, visibility in a tunnel in which the diesel is used is poor and the aldehydes and other irritants are obnoxious after a relatively short exposure. In general, the irritants, such as aldehydes, odors, and smoke follow the trend of the toxic gases, but under improper maintenance they are conspicuously present at all stages of operation. Proper mechanical condition at all times is necessary for a diesel engine to insure against its exhaust containing dangerous concentrations of noxious gases.

The investigation shows the value of field study of diesel locomotives in actual operation, and it was observations so obtained that indicated the amount of carbon monoxide in the exhaust gas as a yardstick for the control of atmospheric conditions. The control of noxious gases in the general air when diesel locomotives are being used should be based upon a carbon monoxide control value of 10 to 20 p. p. m. - BMB 495

889. Braja, M., Trompeo, G.: Contribution to the knowledge of concentrations of carbon monoxide in road tunnels. (Contributo alla conoscenza delle concentrazioni di ossido di carbonio nelle gallerie stradali.) Rass. Med. Ind. (Rome) 33:411-413 (May-Aug.) 1964.

This issue of the journal contains the proceedings of, and papers given at, the "Symposium sull'Ossicarbonismo" held at Turin on April 6, 1963. In this paper are reported the results of studies made of the carbon monoxide content in an Italian road tunnel known as the "Trafaro del Pino." The tunnel is located at the 9,600 kilometer point on Strade Statali (State Road) number 10, which connects Turin with Villanova and Asti, at an altitude of about 495 feet. The tunnel which is slightly more than one-half mile in length, runs in a northwest to southeast direction and has a grade of about 2.5% toward the summit near Chieri. The wind velocity in the tunnel ranges from less than 2 mph. to less than 6 mph. The temperature within the tunnel had a variation of 2.4° to 6.5°C. The intensity of vehicular traffic in the tunnel varied from 162 to 815 vehicles/hour, with the highest numbers being recorded on festive days. The carbon monoxide content was recorded, for several different periods, at five different observation points twice a day for five consecutive days. The content was found to vary from 16 to 193 ppm. The factors which appeared to contribute most to this variation in atmospheric content of CO were the changes in wind velocity, atmospheric pressure, and temperature. Increases in temperature within the tunnel were found to correlate directly with increases in the number of vehicles per hour. - LC

890. Chovin, P.: Studies of Atmospheric Pollution in the Department of the Seine, in 1963. Municipal Laboratory Police Headquarters, Paris, France, 1964.

1963 test results for continuing studies in Paris, France, titled "Carbon Monoxide," "Policemen 1963," "Seine Loop," and "Smokeless Zones," are reported. Previous years' results are confirmed. Surface and underground tunnel measurements of CO in air are compared. The CO pollution level in the air went from "considerable" in 1962 to "serious" in 1963, but in the first 9 months of 1964, the situation reversed to that of 1962. The increase in 1963 is ascribed to the number of new roads and concurrent traffic increase. CO levels in blood were examined in a CO-exposed population consisting of industrial employees, auto drivers involved in accidents, and individuals suffering from CO exposure. Tests for "average real risk" of carbon monoxide absorption by individuals indicated that the auto drivers as a group had a much higher level of carbon monoxide in the blood than that of the rest of the population studied, including workers exposed professionally. - CBK (from French)

891. Conlee, C.J., Kenline, P.A., Cummins, R.L., and Konopinski, V.J.: Motor vehicle exhaust studies at three selected sites. Arch. Environ. Health, in press.

Air quality was studied in relation to motor vehicle densities at three selected sites: the Sumner Tunnel between Boston and East Boston, Massachusetts; the International Peace Bridge across the upper Niagara River between Fort Erie, Ontario, and Buffalo, New York; and Laidlaw Avenue near the Air Pollution Research Facility in Cincinnati, Ohio.

Pollutant concentrations and meteorological findings are presented for each site. Concentrations of pollutants known to be associated with auto exhaust were greater at sites of higher traffic density.

A comparison of particulate pollution levels at the Sumner Tunnel operated as a one-way tube in 1963 with the tunnel carrying two-way traffic in 1961, indicates a definite decrease in pollutant levels.

Other pollutants were assumed to be dispersed in air in the same way as carbon monoxide in determining the contribution by motor vehicles to ambient air for the Sumner Tunnel. Auto exhaust appears to be a prime contributor (greater than 50%) for carbon monoxide, aliphatic aldehydes, benzene-soluble particulate, and oxides of nitrogen. Lead, benzo(g, h, i)pyrene, and coronene may also be assumed to be important pollutants from auto exaust, but they do not meet the requirements for contribution calculations. - Authors' Abst.

892. Cummins, R.L., Konopinski, V.J.: Motor vehicle exhaust concentrations in a road tunnel. Presented at the 1964 Conference of the Amer. Indust. Hyg. Ass., April 29, 1964, at Philadelphia, Pa. USDHEW, PHS, Division of Air Pollution, RATSEC, Cincinnati, Ohio.

The contributions of motor vehicle exhaust to ambient air pollution were studied by using a vehicular-road tunnel as a sampling site. An intensive aerometric study was conducted April 20 through 28, 1963, at the Sumner Tunnel in Boston, Massachusetts. The tunnel is now operated as a one-way tube. Air quality was determined on the fresh air supplied to the tunnel (inlet air), on the air exhausted from the tunnel (exhaust air), and at three sites within the tunnel.

The mean daily concentration of carbon monoxide was 2.3 ppm in the inlet air and 50.8 ppm in the exhaust air. Mean concentrations in the tunnel ranged from 20.5 to 54.2 ppm and increased with increasing distance into the tunnel. Other pollutants exhibited a similar gradient. - Authors' Abst. Modified

893. Di Lullo, G.: Pollution by carbon monoxide of urban air in relation to traffic of vehicles with combustion motors. Nuovi ann. igiene e microbiol. (Rome) 11:141-153 (March-April) 1960.

Studies were made of the concentration of CO at various locations in the city of Naples. It was found that at three locations with heavy traffic and in one where it was extremely heavy, the concentrations ranged from a trace to 150 ppm. In a series of determinations at 19 different locations in the vehicular traffic tunnels of the city there were a few observations of no CO present but mostly the concentrations ranged from 50 to a high (in 3 locations) of 200 ppm. Quoting from an earlier paper by a co-worker, the author gives CO concentration ranges of 10-300 ppm. for New York City; 10-60 for Paris; 0-200 for Berlin; 4-40 for Dresden; and 1-200 for Budapest. - APCA 3999

894. Fieldner, A.C., Straub, A.A., and Jones, G.W.: Ventilation of vehicular tunnels. Part I: Amount and composition of exhaust gases from motor vehicles in relation to the ventilation of vehicular tunnels. J. Amer. Soc. Heating & Ventilating Eng. 32:17-36 (Jan.) 1926, and ibid 32:79-100 (Feb.) 1926.

The road tests on 101 motor vehicles for the purpose of determining the amount and composition of motor exhaust gas from automobiles and trucks of various sizes when operated on grades and at speeds similar to those that will prevail in vehicular tunnels have shown that:

The exhaust gas composition of individual machines varies greatly, and that the controlling factor is the air-gasoline ratio produced by the carburetor adjustment.

The percentage of CO for the majority of cars lies between 5 and 9 per cent.

The average percentage of CO for the first 23 cars tested was 6.7 per cent, which is practically the percentage of CO corresponding to an air-gasoline ratio of 12.4 ratio for developing maximum power.

The average percentage of CO for each class of vehicles under various conditions of test is given in tables and curves.

The average quantity of CO for each class of motor vehicles under certain conditions is given in tables and curves.

The combustible gas in the average automobile exhaust from one gallon of gasoline amounts to 30 per cent of the total heat in a gallon of gasoline.

The great majority of motor cars and trucks are operated on rich mixtures suitable for maximum power but very wasteful from the standpoint of gasoline economy.

On the average, carburetors are set in the winter and not changed in the summer, as shown by the higher percentages of CO found in the summer tests.

The largest quantity of CO will be produced in the 3 per cent grade sections of the tunnel. The CO produced under summer conditions is somewhat greater than in winter conditions. Summer tests should be used in computing ventilation of tunnels, owing to the tunnel becoming heated from the hot exhaust gases. - Authors' Sum.

895. Giubileo, M.: The pollution of city atmospheres caused by motor vehicles. Riv. Combustibili (Milan) 11:157-166 (March) 1957.

Atmospheric pollution due to motor vehicle exhausts was investigated in Milan. Carbon monoxide content in exhaust gases ranged from 0.1 - 8.4%, and compounds from tetraethyl lead were determined. In the central streets the maximum concentration of carbon monoxide was 80 - 100 ppm. and 80 ppm. in tunnels. Lead in the street air was 2.4 - 7.4γ/m.^{3} of air, and in street and garage dusts 0.23 - 5.22 mg./g. The carbon monoxide and lead concentrations were due to amount of local traffic. Pollution from motor vehicles in Milan is comparable to that existing in other cities, and the present concentrations of CO and Pb in atmospheric air are considered harmless. - APCA 1409

896. Giuliani, V., and Belli, R.: Carbon monoxide. Presence in the air of cities and the possibility of poisoning. Folia Med. (Naples) 38:238-248, 1955.

The carbon monoxide in the air of streets, squares, tunnels, and places with heavy traffic, in industrial zones, and in the periphery of Naples was studied. Toxic concentrations were not observed. Persons exposed occupationally for many hours to the highest concentrations showed a carbon monoxide content in the blood within physiological limits and no case of poisoning is on record. - APCA 701

897. Haggard, H.W., and Henderson, Y.: The treatment of carbon monoxide poisoning. J. AMA 77:1065-1967 (Oct. 1) 1921.

In the course of a large series of investigations the authors and their associates have marked out the following standard for exposure: "Multiply the time of exposure in hours by the concentration of the gas in parts per 10,000 of air. If the product equals 3 or less there is no appreciable physiologic effect. If it equals 6, there is sometimes slight malaise. If it equals 9, a headache with some nausea is produced in most people. If it equals 15, the conditions are dangerous for anything beyond brief exposure. If it is more than 15 they are extremely dangerous even for brief exposure.

In the proposed vehicular tunnel under the Hudson, carbon monoxide is not to be permitted to rise above 4 to 5 parts per 10,000, and the time for passage will be from fifteen to thirty minutes. Fieldner and his associates have shown that an automobile engine may produce from 1 to 2 cubic feet of carbon monoxide per minute. Thus, a car warming up in a small closed garage can make an atmosphere dangerous to life within five minutes. Production of carbon monoxide increases on a rich mixture and decreases on a thin one.

The whole toxicity of carbon monoxide has been shown to depend upon its union with hemoglobin.

The therapy of carbon monoxide poisoning depends on the hemoglobin combination and upon the fact that this combination is readily reversible.

898. Hajek, F.: How motor vehicles pollute the atmosphere of cities. Silnicmi Doprava (Prague) 12:4-7, 1964.

The Transportation Res. Inst. measured CO and CO_2, using 2 infrared analyzers at 8 different locations on heavily-traveled streets in Prague in Sept.-Oct. 1962. The concentrations were recorded on a moving chart. Wind velocity was also measured every 15 min. at each test site. The measuring devices were set up on the sidewalk near the curbs at a level approx. the height of an av. pedestrian. The numbers of automobiles, trucks and motorcycles passing by the test sites were counted and the numbers recorded on the charts. The CO_2 concentration did not exceed 0.2% at the peaks and varied in general between 0.1 and 0.15%. Interesting findings were obtained at the Letensky tunnel, at both the entrances and exits of the uphill and downhill roadways. Unfortunately the tunnel is not self-ventilating as its planners had assumed it would be. In the tunnel where it goes downgrade into the center of the city, the CO concentrations were found to reach several peaks of 0.008% to 0.010% (80 to 100 ppm.) during periods of heavy traffic at 9:00 to 11:00 A.M. and 4:00 to 3:00 P.M. A traffic policeman stationed at the exit from this tunnel, during a hot and calm day, had to leave his post because of severe headaches and general malaise. Even during the heaviest traffic in streets which were along an east-west axis (which was that of the prevailing winds) there was no appreciable rise in CO_2 and CO concentrations. In contrast, the heavily-traveled streets on a north-south axis were badly polluted. The proximity of a steam locomotive railway station added to the pollution in 1 of these areas. Since the max. amounts of CO are produced in automotive exhausts during deceleration, acceleration, and idling at intersections, the author suggests that the traffic flow should be directed in such a way as to reduce stopping to a min. by making the streets 1-way speedways during rush hrs. Automobile carburetors should be properly adjusted. Heavily polluted areas, where there is not sufficient air circulation--especially in the hot, windless calm of summer days--should be sprayed with water from spray trucks. Such a fine water-spray would wash down a large portion of the pollutant material. - APCA 6794

899. Henderson, Y., Haggard, H.W., Teague, M.C., Prince, A.L., and Wunderlich, R.M.: Psysiological effects of automobile exhaust gas and standards of ventilation for brief exposures. J. Indust. Hyg. III:79-92 (July) 1921.

This investigation was made in consideration of the construction of a tunnel for motor vehicle traffic under the Hudson River, between New York and New Jersey. The problem as to how conditions in a tunnel under the Hudson would affect the health of the general public needed to be investigated. The total amount of exhaust gases discharged from motor vehicles was expected to be considerable and likely to be increased within the years. Since not only healthy adults, but children and invalids on their way to hospitals would be transported through this tunnel several problems had to be solved which had no precedent. Although other toxic substances are present in smoke and fumes of incomplete combustion, CO usually is the chief course of injury or death caused by asphyxia. Author states that the body of an adult man of average weight contains enough hemoglobin to hold about 600 c.c. of oxygen. If completely saturated, it would hold the same amount of carbon monoxide, one molecule of carbon monoxide replacing one molecule of oxygen in the blood. The absorption of 6 c.c. of carbon monoxide from the lungs produces, then, 1 per cent. of saturation and abolishes 1 per cent. of the oxygen capacity. Other studies discussed in this paper are: Experiments on Men in Six Cubic Meter Chamber; Rate of Absorption of Carbon Monoxide and Standards of Allowable Vitiation of the Air; Concordance of the Standard Here Proposed with the Observations of Other Investigators; Observations in Large Gassing Chamber; Observations in Garages and in the Grand Central Station, New York City; Comparative Toxicity of Pure Carbon Monoxide, Illuminating Gas, Exhaust Gas from Gasoline, Exhaust Gas from Coal Distillate and Gasoline Vapor; and Principal Conclusions. - From Text - Modified

900. Henderson, Y., and Haggard, H.W.: The physiological principles governing ventilation when the air is contaminated with carbon monoxide. J. Indust. Eng. Chem. 14:229-236 (March) 1922.

With the building of tunnels under the Hudson River between New York and Jersey City for the principal use of motor vehicle problems have arisen which have never been extensively investigated. The investigations reported in this paper afford data upon which plans and designs for the ventilation of tunnels may be based. In the principal conclusions, authors state that the general standards agreed upon for periods of a few hours are: When the time in hours multiplied by the concentration of carbon monoxide in parts per 10,000 of air equals 3, there is no perceptible physiological effect. When it equals 6, there is a just perceptible effect. When it equals 9, headache and nausea are induced. When it equals 15 or more, the conditions are dangerous to life.

If the volume of breathing is increased by exercise (even by slow walking, and correspondingly more by physical work) the rate of absorption of carbon monoxide is increased proportionally.

After return to fresh air, the elimination of carbon monoxide through the lungs proceeds at a rate of 30 to 60 per cent reduction of the blood saturation per hour.

In the exhaust gas from gasoline, carbon monoxide is the only considerable toxic constituent. In the exhaust gas from coal distillate (benzene, etc.), and in illiminating gas, there are present accessory toxic substances. - Authors' Conclusions Modified -AGC

901. Henderson, Y., Haggard, H.W., Prince, A.L., and Teague, M.C.: Ventilation of vehicular tunnels. Part II. Physiological effects of exhaust gases from motor vehicles. J. Amer. Soc. Heating & Ventilating Eng. 32:153-158 (March) 1926.

Standards for the ventilation of tunnels, which will greatly reduce the expense of ventilation below that of 1 to 10,000 dilution, are proposed in this paper. Since traffic through the Holland Tunnel consists of passenger cars which take 10 to 12 min. for the trip, and trucks taking 35 to 40 min., the standards worked out afford according to the authors, absolute safety and freedom from any trace of discomfort for healthy and vigorous adults exposed for a period of 45 to 60 min. to CO. Thirty-nine experiments involving nine men and one woman, using a six-cubic meter chamber are described. The essential practical results of this investigation is summed up in a diagram which shows the rate at which CO may be absorbed, and the amounts at which physiological effects may occur. The curves are drawn to show the rate of absorption of CO when air with various concentrations from one to seven parts of CO in 10,000 is breathed. They express the absorption by the blood during one hour of half the amount of CO that would be taken up after a prolonged stay in each of these atmospheres. - AGC

902. Katz, S.H., Bloomfield, J.J., and Trostel, L.J.: Distribution of carbon monoxide in tunnel atmosphere. In: Fieldner, A.C., et al.: Ventilation of Vehicular Tunnels J. Amer. Heating & Ventilation 32:701-718, 1926.

Distribution of carbon monoxide throughout the experimental automobile tunnel was determined to ascertain the most desirable ventilation for the Holland tunnel. This appendix presents in detail the distribution of CO in the tunnel atmosphere under different methods of ventilation, and describes the essentials of the methods and apparatus used in determining it.

The work reported under "Ventilation of Vehicular Tunnels" was inaugurated by the New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission, under a broad public spirited policy which desired that the problems to be undertaken should be handled by recognized and authoritative bodies in order that nothing might be left undone which would contribute to the success of so important a project as the vehicular tunnel connecting the states of New York and New Jersey. - Authors' Abst.

903. Katz, M., Rennie, R.P., and Jegier, Z.: Air pollution hazards from diesel locomotive traffic in a railway tunnel. A.M.A. Arch. Indust. Health 20:493-504 (Dec.) 1959

This paper describes the results of an intensive study of a railway tunnel environment under conditions of fully dieselized train traffic. Atmospheric sampling tests were conducted around the clock on an eight-hour working-shift basis during Oct. 18, 22, and 23, 1957. In all, more than 2,000 observations were made to determine the fluctuations and range of occurrence of contaminant concentrations under a variety of traffic conditions. - From author's introduction

904. Kinney, S. P.: Atmospheric conditions and physiological effects produced on trainmen by locomotive smokes in the Aspen and the Washatch Tunnels of the Union Pacific Railroad. USBMRI 2494, 1923.

Carbon monoxide is the offending gas; temperatures and humidity are increased; and asphyxiation is possible in passing through tunnels. Descriptive data on the tunnels are given. Recommendations include the use of smoke deflectors, the breathing of air from the train's air lines, the wearing of gas masks, and a reduction of the time spent in the tunnels by increasing speed. - BAAP 290

905. Larsen, R.I., and Konopinski, V.J.: Sumner Tunnel air quality. Arch. Environ. Health 5:597-608 (Dec.) 1962.

Aerometric studies of the Boston Sumner tunnel were conducted in July and Sept., 1961. The 35,000 vehicles/day that traveled this 2-way tunnel produced an average carbon monoxide concentration of 70 ppm. in the tunnel, with instantaneous peaks as high as 257 ppm. The soiling index values in Cohs/1000 ft. of air were approximately 1 for tunnel inlet air, 2 for the toll station, and 4 for tunnel outlet air. The amount of pollutants/vehicle mile of tunnel travel were: carbon monoxide 60 gm, total suspended 0.36, organic suspended 0.16, and paticulate lead 0.31. The relative significance of vehicular exhaust on outdoor concentrations was estimated for the suspended particulates measured. Ranked in order from most to least significant, the 1st several pollutants were caronene, benzo(a)pyrene; benzo (g, h, i)perylene, lead total organics, iron, titanium, and total suspended particulate. - APCA 5026

906. Lawther, P.J., Commins, B.T., and Henderson, M.: Carbon Monoxide in Town Air. An Interim Report. Ann. Occupat. Hyg. 5:241-246 (Oct.-Dec.) 1962.

When the Suez crisis resulted in the rationing of petrol it was realized that an opportunity was at hand to measure air pollution in the city of London in the presence of minimal petrol traffic. A series of tests was carried on then and until 6 months after the termination of rationing. When petrol was rationed, CO virtually disappeared from the street; when car-traffic reappeared, the CO concentrations rose markedly and on 1 day reached a figure of 235 ppm. On this calm day, a concentration of 360 ppm. was also found in samplings taken on the pavement at Oxford Circus. Carbon monoxide analyses at Oxford on Sept. 1, 1958, had shown a mean concentration for an 8-hour daytime period of 36 ppm., with a maximum concentration of 155 ppm. during the evening rush hour. In the autumn of 1961, a series of analyses was begun of the air of Fleet Street compared with that of nearly Mitre Court (relatively uninfluenced by traffic). A figure in the text shows the mean hourly concentration, on Jan. 29, 1962, to vary from 0 to nearly 60 ppm. and the maximum concentration at that same hour (18th) to be 100 ppm. Carbon monoxide concentrations in the Blackwell tunnel have been found to reach a mean hourly concentration of 295 ppm. in the morning rush hour. At the Rotherhithe tunnel, a transient peak value of 500 ppm. was found. In the discussion of this paper the authors state that they have been lead to conclude that detailed comparison of carbon monoxide concentration in the air of different cities is of limited value since they will all depend on the density of traffic in the streets and the weather. And that it is reasonable to believe that in congested streets in almost any modern city concentrations of carbon monoxide exceeding 300 ppm. may be reached in calm weather and that concentrations exceeding 100 ppm. may be found not uncommonly. Also that the significance of these figures is not clear-cut since in this study they have not been related to concentrations of carbon monoxide in the blood of people working in the streets. It is stated that the figure of 30 ppm., which has been adopted by the State of California Department of Public Health as the maximum allowable concentration in ambient air, and the arguments on which this decision was based, appear to the authors to be sound. - APCA 5364

907. Los Angeles safeguards underpass air purity. American City 68:96-97 (June) 1953.

Continuously sampling carbon monoxide detectors in the underpass beneath Los Angeles International Airport will: (1) regulate aerating fans; (2) signal when air contamination reaches a safety limit; and (3) halt traffic entering the underpass when contamination becomes unsafe. The detector consists of a catalyst and thermocouple cell, called a hopcalite unit, and a graphic recording potentiometer. A fan house at each end of the subway contains 2 analyzers, 2 exhaust-, and 2 supply-fans. Fresh air ducts beneath the divided roadway between the 2 fan houses supply air through vents. Similar exhaust ducts with intake slits run along the underpass wall. Contaminated air is discharged through roof stacks at the fan houses. Exhaust and supply fans are regulated so that the rate of supply is proportional to the rate of exhaust. Air samplers are located in wall-recesses, 2 at either end of the underpass. - LC

908. Massmann, W.: Dangers in railway tunnels from air pollution. Arch. Gewerbepathol. Gewerbehyg. (Berlin) 14:129-189, 1955.

This lengthy paper on air pollution in railway tunnels gives a mass of information on the subject and an account of an investigation of 2 railroad tunnels in Germany. Descriptions are given of accidents which have occurred through carbon monoxide poisoning and the inhalation of accumulated smoke. Studies of gas and solid matter concentrations were made in the 2 tunnels under a variety of circumstances of traffic, types of fuel used, and of meteorological conditions. The experimental results are presented in detail. It is considered that definite danger exists of acute and chronic carbon monoxide poisoning. Poisoning by hydrogen sulfide and sulfur dioxide is thought not to be a danger, although relatively high concentrations of SO_2 up to 10 ppm. were found occasionally. The precautions which should be taken to prevent carbon monoxide poisoning in tunnel workers and the provision of adequate first aid centers are described. - APCA 1018

909. Miranda, J.M., Konopinski, V.J., and Larsen, R.I.: Carbon monoxide control in a high highway tunnel. Presented May 6, 1965, Houston, Texas, Annual Amer. Indust. Hyg. Conference. Amer. Indust. Hyg. Ass. J., in press.

Interstate Highway 70 is scheduled to be tunneled 1.6 miles through the Rocky Mountains at a 2-mile-high elevation 60 miles west of Denver. Both elevation and carbon monoxide in the tunnel will tax the oxygen-carrying capacity of the blood of tunnel employees and individuals traveling through the tunnel. The combined physiologic load of elevation and carbon monoxide is evaluated. It is recommended that carbon monoxide concentration in the tunnel be maintained below 50 ppm. with 1-hour averages no higher than 100 ppm. - Authors' Abst.

910. Pistoue, S.: On the installation of ventilation in the road tunnel of Monte Bianco. Fumi & Polveri 3:219-222 (July) 1963.

On Sept. 15, 1962, the Monte Bianco vehicular tunnel through the Alps was officially opened with combined Italian-French ceremonies. The over-all length of the tunnel is about 12 km. Because of this length it was necessary to install a major ventilation system to carry out the air which has been contaminated by automotive fumes and to bring in fresh air. Automotive exhaust fumes, especially those from the heavy lorries, could easily become dense and acrid if they collected in the tunnel, decrease visibility and cause irritation to the eyes, and the respiratory system. Of particular concern would be the building up of the CO level. With a maximum capacity of 420-450 vehicles/hour, moving at an average speed of 60 km./hour, the level of the CO content in the air could be about 1 part/10,000 parts. A level of 4 times that high, if endured for an hour, would cause fairly severe physiological disturbances. Traveling at the velocity of 60 km./hour and in the traffic pattern now set up for the tunnel, there could be about 80 or 90 vehicles present at any 1 time in the tunnel. It was calculated that it would be necessary to provide for 4 changes/hour of air in the tunnel. On that basis, the admission of fresh air would need to be 2,160,000 m.^{3}/hour, or 600 m.^{3}/second. Because of the condensation of the moisture content of the air, a drainage pipe system was needed. At each of the 2 centers in the tunnel, there are 4 centrifugal ventilators for the emission of fresh air, 3 for the extraction of polluted air, and 1 held in reserve. Each ventilator is supplied with 2 electric motors with 2 speeds for each. The velocity of the air has to be carefully regulated to prevent areas of accumulation of pollutants. The 8 motors of the ventilators are very strong, having a combined strength of 600 cv (1 cv = 0.986 horsepower). Units now being constructed will be of 4000 cv for each of the 2 centers, or a total of 8000 cv. - APCA 5680

911. Rennie, R.P., Jegier, Z., and Katz, M.: Effect of diesel locomotive operation on atmospheric conditions in a railway tunnel. Canadian J. Chem. Eng. 123-128 (Aug.) 1960.

An extensive study was made over a 7 day period to determine if it would be feasible, from an air pollution view point, to operate diesel locomotive powered trains trough the St. Clair Tunnel. The test involved the passage of approximately 200 diesel powered freight and passenger trains through the tunnel; 3000 air samples were taken and measurements were made on air flow and smoke density. Concentrations of carbon monoxide, nitrogen dioxide, total oxides of nitrogen, aldehydes, sulfur dioxide, carbon dioxide, and oxygen were determined. The sampling methods, sampling equipment, analytical procedures, and test equipment used for this particular investigation should be applicable to a variety of air pollution problems met in the chemical industry. - APCA 3274

912. Schrenk, H.H.: Results of laboratory tests. Determination of concentration of carbon monoxide in blood. Federal Security Agency, U.S. PHSB No. 278, 1942, Washington, D. C., pp. 36-57.

The levels of carbon monoxide found in the blood of traffic officers stationed in the Holland Tunnel during a period of two hours fall within the range of blood carbon monoxide concentration values observed in cigarette smokers with no occupational exposure to carbon monoxide. Amounts of carbon monoxide absorbed during tunnel duty appear to be added to amounts absorbed as a result of smoking. No complaints of ill health attributable to carbon monoxide exposure were made by these men. On the basis of earlier work, none was to be expected.

In the section "Other exposures to CO," author summarizes the results of the recent survey made and of the data presented in the literature. It appears that in most workplaces where there is reason to suspect that CO escapes into the breathing zone of the workers, the CO concentration usually remains below 1.0 part per 10,000 (100 p.p.m.). The commonest source of greater exposure than this is the operation of gasoline engines in an unventilated or a poorly ventilated room. - Author's Sum.

913. Sievers, R.F., Edwards, T.I., and Murray, A.L.: A Medical Study of Men Exposed to Measured Amounts of Carbon Monoxide in the Holland Tunnel for 13 Years. Federal Security Agency, U.S. PHSB No. 278, 1942, Washington, D. C., 74 pp and J. AMA 118:585-588 (Feb.21) 1942.

Medical examinations of 156 traffic officers on duty at the Holland Tunnel for 13 years and four months were made as a practical test of the effectiveness of the medical and engineering control methods set up for their protection. About half of these officers had been on tunnel duty every working day of this period. Average carbon monoxide exposure throughout the tunnel for all hours of the day was approximately 70 ppm. Results of medical examinations of men on duty for the first five years showed them to be in excellent physical conditions. No evidence of symptoms attributable to carbon monoxide intoxication and for sequelae of acute episodes was found. The effects of both smoking habits and of occupational exposure to carbon monoxide concentrations in blood samples were analyzed by the Van Slyke method. The lowest concentration value, expressed as percent of hemoglobin combined with carbon monoxide, was 0.5; the highest value was found in a tunnel officer, a heavy smoker, coming directly from unusually heavy atmospheric exposure, was 13.1. No signs or symptoms attributable to carbon monoxide were observed within this range. Concentrations of carbon monoxide in the blood of toll collectors on the holiday selected for observation ranged up to 15.1 percent, expressed as percent of hemoglobin combined with carbon monoxide.

Authors do not feel that there is reason to assume that prolonged exposure to these concentration levels will result in injury to health. Precautions in force in the Holland Tunnel set up for the elimination of the possibility of acute exposure is to be extended in order to protect the health of all persons unavoidably exposed to carbon monoxide. - Authors' Abst. Modified-AGC

914. Speizer, F.E., and Ferris, B.G., Jr.: The prevalence of chronic nonspecific respiratory disease in road tunnel employees. Amer. Rev. Resp. Diseases 88:205-212 (Aug.) 1963.

Results are presented of an epidemiological investigation of the respiratory symptoms and pulmonary functions of a group of men exposed to automobile exhaust in the Summer Road tunnel in Boston. Chronic nonspecific respiratory disease was more prevalent in men who had worked in the tunnel for more than 10 years than in those with a shorter time of employment. Chest colds were also more frequent in this group. The size of the sample did not permit proper assessment of the effect of age or cigarette smoking on this population. The maximal expiratory flow rate, as measured with a Wright peak flowmeter, was significantly lower in the workers with chronic nonspecific respiratory disease than in the rest of the workers studied. APCA 5998

915. Tyler, H.W.: Safety stressed in Seattle's vehicular subway. American City 71:108-109 (Aug.) 1956.

A number of small fans are used in Seattle's vehicular subways to force in fresh air at a high velocity, and to discharge contaminated air naturally through openings in the ceiling. In the detector cells, carbon monoxide is oxidized in a catalytic exothermic reaction to carbon dioxide and the thermopile produces an electromotive force in proportion to the carbon monoxide present in the air. Nine fans are started when the carbon monoxide content reaches 1.5 parts/10,000 in one section; 72 fans operate at 3 parts/10,000; and stop signs flash in the tunnel at 6 parts/10,000. - LC

916. Waller, R.E., Commins, B.T., and Lawther, P.J.: Air pollution in road tunnels. British J. Indust. Med. 18:250-259 (Oct.) 1961.

As a part of a study of pollution of the air by motor vehicles, measurements have been made in two London road tunnels during periods of high traffic density. The concentrations of smoke and polycyclic hydrocarbons found there are much higher than the average values in Central London, but they are of the same order of magnitude as those occurring during temperature inversions on winter evenings when smoke from coal fires accumulates at a low level.

An attempt has been made to relate the concentration of each pollutant to the type and amount of traffic. Both diesel and petrol vehicles make some contribution to the amounts of smoke and polycyclic hydrocarbons found in the tunnels, but in the case of smoke, fluoranthene, 1 :2-benzpyrene, pyrene, and 3 :4-benzpyrene, the concentrations appear to be more closely related to the density of diesel traffic than to that of petrol traffic. The concentrations of lead and carbon monoxide have also been determined, and these are very closely related to the density of petrol traffic. During the morning and evening rush hours the mean concentration of carbon monoxide was just over 100 p.p.m. and peak values up to 500 p.p.m. were recorded at times. Oxides of nitrogen were determined in some of the experiments and there was always much more nitric oxide than nitrogen dioxide. Eye irritation was experienced but its cause was not investigated.

The concentration of pollution in the tunnels does not appear to be high enough to create any special hazards for short-term exposures. The atmosphere at peak periods may become very dirty and unpleasant and the concentration of carbon monoxide would be sufficient to produce some effect over a period of several hours! continuous exposure. The total emission of pollution from road vehicles must still be small in comparison with that from coal fires, but the effect of traffic on the concentration of smoke, polycyclic hydrocarbons, carbon monoxide, and lead in the air of city streets deserves continued study. -Authors' abst.

917. Yant, W.P., Levy, E., Frevert, H.W., and Marshall, K.L.: Carbon monoxide and particulate matter in air of Holland Tunnel and metropolitan New York. USBMRI 3585, 1941, 69 pp.

The CO and particulate matter (PM) in the air of the Holland Tunnel and in the air of metropolitan New York at various places both at and away from the tunnel were studied to determine whether the tunnel had a significant effect on these contaminants in the atmosphere in the immediate vicinity. The study was started in April 1932 and continued at intervals until February 1933. PM was studied at 2 seasons of the year, spring (April-June 1932) and winter (February 1933). CO was studied during August and September 1932. Concentration of CO tends to vary with the traffic through the tunnel and in different parts of the tunnel; it was highest in the exit or upgrade section. Concentration in the spring in the upgrade section (average daily traffic 15,000 cars) averaged ca. 160 ppm during the high-traffic hour (8 a.m. - 8 p.m.); in the winter, 110 ppm (average traffic 11,000 cars). At all seasons, CO concentration between 8 p.m. and 8 a.m. averaged ca. 50 ppm. From 11:30 a.m. - 10:30 p.m. on spring Sundays (average traffic 20,000 cars), CO averaged 170 ppm. Pb content of both suspended and deposited material collected from the intake part of the tunnel was lower than that of the material from the exhaust (0.04 and 0.9% in suspended material). Arsenic was higher in material from the intake than from the exhaust (0.044 and 0.016% in suspended material). Deposited material from the intake contained less volatile matter than that from the exhaust (27 and 57%). The composition of the volatile matter and ash in material from intake and exhaust was similar. Concentration of PM in the air of the south tube and in the discharge did not exceed that in the intake air until traffic reached 300 cars/hour and CO 40 ppm. Concentrations of tunnel-added PM varied directly with CO. The amount of tunnel-added PM in the discharge air was ca. 7 grains/car. The tunnel air contained ca. 1500 million microscopically visible particles/mg. PM. The size of particles collected from intake air was similar to those from exhaust air (geometric mean, 0.41 and 0.40 μ); there were no significant differences in different seasons. Results of 46 determinations of weight concentration of PM in the intake air of the tunnel ranged from 0.00-0.82 mg./m.^{3}, with an average of 0.30. Weight concentration in spring was higher than in the winter. In 1 section spring concentration was 0.49-0.86, average 0.66 mg./m.^{3}. Concentration of tunnel-added CO and PM in the discharged-air streams fell to ca. 10% of that at the stack discharge within 30 feet, to ca. 6% within 100 feet and 2% within 150 feet. The concentration of CO and PM in the air in the immediate vicinity of the tunnel did not differ significantly from that in the air in other parts of metropolitan New York. - Authors' Abst.

ADDITIONAL REFERENCES

Books

918. Air Conservation. Rept. Air Conservation Comm. Pub. 80, Amer. Ass. Advancement Sc., Washington, D.C., 1965, 335 pp.

Contents: I. Air conservation and public policy. II. Summary of the facts. III. Background reports. 1. Meteorology. 2. Pollutants and their effects. Sulfur and its compounds. Carbon monoxide. Carbon dioxide. Oxides of nitrogen. Photochemical air pollution. Particulate matter. Lead and other deleterious metals. Fluorides. Air pollution as a factor in environmental carcinogenesis. Economic poisons as air pollutants. Radioactive pollution of the atmosphere. III. Metropolitan organization for air conservation. IV. Air conservation and the law. V. Air pollution control. VI. Socio-economic factors. VII. Air pollution and urban development. This report is the result of the efforts of members of the commission and a large number of authorities in many fields of endeavor. - APCA 7201

919. **Air Pollution Measurements of the National Air Sampling Network: Analysis of Suspended Particulate Samples Collected 1953-1957. U.S. DHEW, PHS, Div. of Air Poll., Cincinnati, Ohio, 1958, 259 pp.**

Basic data are presented on suspended particulate matter in the air over the U.S. The following information is included: the U.S. Public Health Service's National Air Sampling Network, its historical background, and current operations; the atmospheric pollutants measured; the selection of station locations, sampling equipment and procedures used; the sampling scheduling; sampling site descriptions and listings of participating organizations; directions of how to find data from a particular city or state; tables containing the data obtained; statistical interpretations; and a description of analytical methods. Hope is expressed that comprehensive analysis of these raw data will help determine trends and patterns of air pollution in the U. S. and aid the public-spirited citizen in understanding this relatively new environmental problem. -APCA 2283

920. **Air Pollution Measurements of the National Air Sampling Network. Analyses of Suspended Particulates. U.S. DHEW, PHS, Pub. No. 978, Div. of Air Poll., Washington, D.C., 1962, 217 pp.**

This publication was prepared for the Natl. Conference on Air Pollution held in Wash., D.C., on Dec. 10-12, 1962. On Jan. 1, 1957, major revision of the network operations was initiated. With these revisions the network became truly "national." There are currently 250 sampling stations in the network, 213 urban and 37 nonurban. Of the urban stations, 73 sample every yr. and 140 sample every other yr. Thus, in any 1 yr. there are 180 stations actively collecting samples, 143 urban and 37 nonurban. Every yr. urban sampling stations are usually located in the largest city, by population, of the 50 states, the District of Columbia, and Puerto Rico. In addition there are frequently several every-other-yr. stations in operations, some of which have been operated during the off yr. by the respective State agencies. Particulate matter collected by the Natl. Air Sampling Network is made up of the small particles which remain in suspension in the air for varying periods of time. The national urban mean concentration of suspended particulates for 1957-61 was 104 μg./m.^{3} with a max. concentration of 1706 μg./m.^{3}. The frequency distribution of mean concentrations, which for 190 cities ranged from 46 to 224 μg./m.^{3} is shown graphically in a figure in the text. This information is contained in Part I of the publication. Other parts of the publication are concerned with Data tables: Sampling site description and participating organization; Analytic methods; Explanation of statistical terms. -APCA 5219

921. Air pollution measurements of the National Air Sampling Network. Analyses of suspended particulates, 1963. U.S. DHEW, PHS, Div. of Air Poll., Cincinnati, Ohio, 1965, pp. 87.

In 1963, the National Air Sampling Network (NASN) encompassed some 200 stations. This report presents the results of analyses performed on samples collected at these stations in 1963 and also results of analyses performed in 1963 on some samples collected in previous years. These results are tabulated in the summary tables. The mean concentration of suspended particulates for 168 urban NASN stations in 1963 was 92 µg./m.^{3} This level is not significantly different from the mean for the previous 2 years (92 µg./m.^{3} in 1961; 89 µg./m.^{3} in 1962). Concentrations in individual samples ranged from a minimum of 5 µg./m.^{3} to a maximum of 710 µg./m.^{3} The mean concentration of benzene-soluble organics at urban stations was 6.5 µg./m.^{3}; this level also has changed little from the previous 2 years (6.9 µg./m.^{3} in 1961; 6.6 µg./m.^{3} in 1962). Concentrations in individual samples ranged from 0.2 µg./m.^{3} to 128.3 µg./m.^{3} The mean concentration of suspended particulates for the 32 nonurban stations was 27 µg./m.^{3}, a level that has not fluctuated significantly in the past 6 years. Analysis of data on particulate pollutants in 100 selected cities, for the period 1957 through 1963, shows that concentrations of most of the individual particulate pollutants analyzed are related to the concentration of total suspended particulates. Benzene-soluble organic matter averages about 7-1/2% of urban particulates. The sulfates average about 10%, iron a little over 3%, and lead less that 1% of the suspended particulates in those cities for which data are available. Nitrate concentrations are an exception, showing little apparent relationship to the concentration of total suspended particulates and averaging between 1 and 3 µg./m.^{3} A limited investigation was made of arsenic concentrations in samples from 10 selected urban stations and 2 nonurban stations. Typical concentrations were of the order of 0.02 µg./m.^{3} Concentrations in individual urban samples ranged from less than 0.01 µg./m.^{3}, the threshold of detectability, to 1.00 µg./m.^{3} The maximum arsenic concentration for any individual nonurban sample was 0.03 µg./m.^{3} - APCA 65-33

922. Aviation Toxicology. An Introduction to the Subject and a Handbook of Data. The Blakiston Co., New York, Toronto, 1953, pp. 120.

This handbook on aviation toxicology provides toxicity data on chemicals of special interest in aviation.

CO is the only toxic gas for which allowable concentration limits have been generally prescribed in aviation. The allowable limit of concentration for CO set by military and civilian agencies of different countries vary somewhat. The average limit is one part in 20,000 parts of air (14 b) for civil airplanes in the U.S. In moderate altitudes carbon monoxide does not have any ill effects. Author points out, however, that careful laboratory tests have shown that vision is somewhat impaired at, or even below, this concentration. The concentration of carboxyhemoglobin in the blood stream at high altitude, and the general properties and occurrence of CO are discussed in this book. There are diagrams showing time-concentration curves of CO toxicity. - AGC

923. Bokonjić, N.: Stagnant Anoxia and Carbon Monoxide Poisoning. A Clinical and Electroencephalographic Study in Humans. Electroencephalography & Clinical Neurophysiol., 1963, Suppl. 21, 102 pp.

A detailed description and comparison of clinical and electroencephalographic symptoms in human suffering from acute anoxia due to strangulation and carbon monoxide poisoning is provided in this publication. The important differences of these two types of anoxia are clinical and electroencephalographic syndromes which require differential prognosis. The association established between duration of unconsciousness and recovery prospects, and clarification of the influence of gas and cardiovascular failure on the final outcome, are of particular prognostic value. - AGC

924. Drinker, C.K.: Carbon monoxide asphyxia. Oxford University Press, New York, 1938, 276 pp.

The chief purpose of this volume is to supply information to individuals working in fields of industry in which carbon monoxide is a lively problem. The intricate physiology and biochemistry of oxygen lack and the problems of carbon monoxide asphyxia are discussed. There are eight chapters on following subjects: Respiratory Physiology and Biochemistry of Carbon Monoxide Asphyxia. Acute Poisoning by Carbon Monoxide and the Problem of the After-Effects of Carbon Monoxide Asphyxia. What Constitutes Harmful Exposure to Carbon Monoxide. Some Statistics on Carbon Monoxide Asphyxia and Common Sources of Carbon Monoxide. The Pathology of Carbon Monoxide Asphyxia. The Problem of Chronic Exposure to Carbon Monoxide. Treatment of Carbon Monoxide Asphyxia. Detection and Determination of Carbon Monoxide in Air and Body. - AGC

925. DuBois, K.P., and Geiling, E.M.K. Textbook of Toxicology. Oxford University Press, New York, 1959, 302 pp.

This textbook, although intended for students interested in the general principles of toxicology and in facts with practical applications, is also useful to the practical toxicologist and research worker. There are 15 chapters, tables, figures and an index. The detection, mode of action, occurrence, pathology, toxicity and symptoms, and treatment of carbon monoxide are discussed in chapter five: Air-Borne Poisons - Gases. - AGC

926. Edell, G.M.: Determination of small amounts of carbon monoxide in air. (Abstract of Thesis, Syracuse Univ.) Indust. Eng. Chem. 20: 275 (March) 1928.

It seemed desirable to test air for smaller concentrations of carbon monoxide than had previously been reported. Oxidation by means of iodine pentoxide was selected as the most accurate method in use. Several test analyses were made from each of four different concentrations of carbon monoxide in air, using an apparatus modeled after Graham's portable type with the bromine tube omitted. One-liter samples of the two more concentrated mixtures and 3-liter samples of the dilute mixtures were used.

It was found that only the purest iodine pentoxide should be used. Even then there was a constant, though small, liberation of iodine when pure air was drawn through the tube; the rate of decomposition, however, was nearly uniform. It had to be determined and corrections made in computing the results of the analyses. One tube filled with an inferior grade of iodine pentoxide gave untrustworthy results due to a high and uneven rate of decomposition. Water displacement of the gas sample from the reservoir and sampling bulb gave results fully as accurate as vacuum displacement.

Analytical Results

No. of Determinations	Carbon Monoxide		Deviation of Determined Percentages from Computed		
	Computed Per Cent	Determined Per Cent	Average Per Cent	Maximum Per Cent	Minimum Per Cent
6	0.0575	0.0599	+0.0024	+0.0031	+0.0010
4	0.0094	0.0109	+0.0015	+0.0023	+0.0007
5	0.0018	0.0027	+0.0009	+0.0020	+0.0001
7	0.0008	0.0011	+0.0003	+0.0008	+0.0001

The excellent checks obtained on the work of other investigators and the accuracy of determinations on still more dilute concentrations mark the method as one having greater refinement than is generally known, and one whose limit of usefulness has not yet been determined. - Author's Abst.

927. General Assembly of the Commonwealth of Penna., Capitol Bldg., Harrisburg, Penna.: Automotive Air Pollution. Joint State Government Commission. (Feb.) 1963 - 51 pages.

This is a report by the Chairman, B. Royer, of the Panel of Tech. Advisors on Automotive Air Pollution to the Joint State Govt. Comm. The report consists of a summary and conclusions, recommendations, extensive information as assembled in appendix A through E, and appendix F which is a bibliography of 38 references. The Panel recommended that action be taken on the following points: (1) That means be provided to conduct an analytical survey of atmospheric contaminant concentrations from the automotive source in selected localities of the Commonwealth. This should be of sufficient scope to include seasonal and annual variations. (2) That a small technical group be established for an additional 2 years to advise concerning any technical programs, such as are recommended in later paragraphs. (3) That positive crankcase ventilating devices be required as factory-installed equipment on all new cars registered in Penna. beginning Jan. 1, 1964. (4) That the established automobile inspection system in Penna. be utilized to extend the regular required semiannual inspections to include several specific items having to do with the ignition system, air clearner, carburetor, and any blow-by device on cars so equipped. However, the Panel recommends that action be postponed pending the outcome of studies outlined in the next 2 paragraphs. (5) That, although in the opinion of the Panel a system requiring regular maintenance would be effective in substantially reducing emissions, provision be made to undertake a corroborating test program on passenger cars representing a cross section of makes and models. (6) That concurrently with the testing program recommended in paragraph 5 the Secretary of Revenue be consulted with respect to the practicability of expanding the non-existing inspection service to include the items listed in paragraph 4. (7) That the Motor Vehicle Code be amended to cite such motor vehicles as operate on the highways with continuous visible emissions other than water vapor and to require the owners of such vehicles to correct the situation by such adjustments or repairs as may be necessary. - APCA 6601

928. Grollman, A.: Pharmacology and Therapeutics. A textbook for students and practitioners of medicine and its allied professions. Lea & Febiger, Philadelphia, 1960.

It has been estimated that once equilibrium is established between body and atmospheric concentrations of CO - a matter of some hours - each part per million of CO in the air up to 100 ppm will inactivate one-sixth of 1% of hemoglobin. Thus, a man exposed for some time to 100 ppm of CO - the industrial threshold limit - might be expected to have as much as 15% blood saturation with this gas. There is considerable individual variation in the percentage of carboxyhemoglobin at which symptoms appear and atmospheric levels of 100 ppm are not ordinarily associated with symptoms; at 400 ppm, headache, weakness, nausea, and dizziness appear; at 600 ppm, tachycardia with danger of collapse; at 800 ppm, fainting; and at 1,000 ppm, coma, convulsions, and death. - AGC

929. Grut, A.: Chronic Carbon Monoxide Poisoning, a Study in Occupational Medicine. Ejnar Munksgaard, Copenhagen, 1949, 229 pp.

The following topics are discussed in twelve chapters: 1. Introduction, 2. Exposure to Carbon Monoxide, 3. Acute Carbon Monoxide Poisoning, 4. Chronic Carbon Monoxide Poisoning, 5. Hyperthyroidism Following Exposure to Carbon Monoxide, 6. Diagnosis of Chronic Carbon Monoxide Poisoning,

7. Aggregate Result of Examinations of Producer Gas Drivers and Other Workers Exposed to Carbon Monoxide, 8. The Individual Working Processes Connected with Producer Gas Driving, 9. Development and Course of Chronic Carbon Monoxide Poisoning, 10. Variations in Susceptibility to Carbon Monoxide, 11. Pathogenesis and Pathological Anatomy, and 12. Treatment and Prophylaxis.

Various methods to determine the CO content of the air and of COHb are described. Exposures are ascertained by the detection of a pathological COHb% of CO in the air of places of work or by examination of the working process.

The occurrence and severity of chronic CO poisoning of drivers and mechanics of motor vehicles, respectively of fuel trucks, of traffic policemen and workers in tunnels are discussed.

Acclimatization to CO has been experimentally verified in animals but experiments with man are not convincing. Pathologic neurological symptoms and histological changes have been found in the brains of dogs exposed to 0.01% CO, but only slight histological changes have been described in human beings after chronic CO poisoning. The bibliography contains 180 references. - AGC

930. Henderson, Y., and Haggard, H.W.: Noxious Gases and the Principles of Respiration Influencing Their Action. Reinhold Pub. Corp., New York, N.Y., 1943, pp. 294.

This is the second edition of probably the first monograph in this special field. It contains 18 chapters, each followed by bibliographical references; of supplementary statement on breathing machines, a foreward and an index. The titles of the chapters are: 1. General survey of the field. 2. Elements of respiration. 3. The respiratory functions of the blood and their laws. 4. Practical applications of the laws of gases and vapors. 5. Principles determining absorption, distribution and elimination of volatile substances. 6. The significance of standards for physiological response to various concentrations of gases and vapors. 7. Classification of noxious gases and vapors. 8. Group I. Irritant gases. 9. Group I (cont'd.). Special characteristics of various irritant gases. 10. Group IIA. Asphyxiation and simple asphyxiants. 11. Group IIB. Chemical asphyxiants. 12.-15. Group III. Volatile drugs and drug-like substances. 16. Group IV. Inorganic and organomentallic gases. 17. Methods of resuscitation and comparison of various treatments. First aid. and 18. Prevention of poisoning by noxious gases. - AGC

930a. Levine, B.S. (translator): Demidov, A.V., and Mokhov, L.A.: Rapid Methods for the Determination of Harmful Gases and Vapors in the Air. Medgiz, Moscow, 1962. U.S.S.R. Literature on Air Pollution and Related Occupational Diseases, Vol. 10, 1964, 108 pp., U.S. Dept. Commerce, CFSTI - TT64 - 11767.

Following a short discussion of the bases of the rapid methods and of suggestions on the collecting of samples, information is given in considerable detail on various inorganic substances and on various organic substances in the air. The inorganic substances are: carbon monoxide (CO), nitrogen oxides, hydrogen peroxide (H_2O_2), ozone (O_3), chlorine (Cl_2), hydrogen chloride (HCl), hydrogen sulfide (H_2S), carbon bisulfide (CS_2), ammonia and aliphatic amines, arsenic hydride or arsine (AsH_3), antimonous hydride (SbH_3), fluorine (F_2), sulfur dioxide (sulfurous anhydride, or sulfur dioxide, SO_2), mercury vapor (Hg), hydrocyanic acid (HCN), nickel tetracarbonyl $[(Ni(CO)_2]$, carbon dioxide (CO_2). The organic substances are: formaldehyde (HCOH), ethyl alcohol vapor (C_2H_5OH), liquid fuel vapor, phosgene ($COCl_2$), acetylene (C_2H_2), benzene vapor, ethylene oxide (C_2H_4O), aniline ($C_6H_5NH_2$), acetone (CH_3--CO--CH_3). There are six appendices which give such information as volume, percent, and weight conversion formulas and tables; tables of ready calculated factors; and specific gravity equivalent concentrations for some acids. - APCA 64-293

931. Lewin, L.: Die Kohlenoxydvergiftung. Ein Handbuch für Mediziner, Techniker und Unfallrichter. (Carbon Monoxide Poisoning. A Manual for Physicians, Engineers and Accident Investigators.) Julius Springer Verlag, Berlin, 1920, 370 pp.

This comprehensive treatise written in German, covers various fields of CO poisoning. Author considers CO, a product of many sources most closely related to human activity, to be one of the most widely spread poisons, scourging mankind with the instant fire became known to man. Author begins the first part entitled Chemical, Technical and General Toxicology, with a history of CO. He describes its natural occurrence and also the chemical formation. The second part consists of clinical discussions: Acute and Chronic CO Poisoning and its Consequences. The pathological, anatomial, forensic and therapeutic problems are discussed in the last part which also includes sections on statistics, prevention and on treatment of CO poisoning. - AGC

931a Motor Vehicles, Air Pollution, and Health. Part I. Summary - A Review of the Problem. II. Effects of Motor Vehicle Pollution on Health. III. Air Pollution from Motor Vehicles. A Report of Surgeon General to the U.S. Congress in compliance with Public Law 86-498, The Schenck Act, June 1962. USDHEW, U.S. Government Printing Office, Washington, D.C., 1962.

The report is the result of 2 yrs. intensive research conducted by the Div. Air Poll., U.S. Public Health Service, following legislation introduced by Congressman Paul F. Schenck (Ohio) and signed into law June 8, 1960 as PL 86-493. This law directed the Surgeon General of the PHS to conduct "a thorough study for the purpose of determining, with respect to the various substances discharged from the exhausts of motor vehicles, the amount and kinds of such substances which, from the standpoint of human health, it is safe for motor vehicles to discharge into the atmosphere under the various conditions under which such vehicles may operate." It further directed the Surgeon General to report back to the Congress his findings and recommendations not later than June 8, 1962. Although much of the information in the report is based on studies still in progress, it indicates clearly that pollutants from automobiles, trucks, and buses have harmful effects on man, vegetation, and many materials. - APCA

932 Restoring the Quality of Our Environment. Report of the Environmental Pollution Panel of the President's Science Advisory Committee. The White House. Washington, D.C., Nov. 1965, pp. 317.

The information in this very extensive monography is assembled under the major headings of: Effects of pollution. Sources of pollution. In which direction should we go? Recommendations. Under effects of pollution, consideration is given to health effects; effects on other living organisms; impairment of water and soil resources; pollution effects of detergents; deterioration of materials and urban environments; climatic effects of pollution. Sources of pollution discussed are: municipal and industrial sewage, animal wastes, urban solid wastes, mining wastes, consumer goods wastes, and unintentional releases. Information is given, concerning recommendations, under the following headings: principles, actions, coordination and system studies, baseline measurement programs, development and demonstration, research, manpower, and incompleteness of recommendations. There are 11 extensive appendixes (39-291) and a fairly detailed subject index (293-317). - APCA

933. Sayers, R.R., and Davenport, S.J.: Review of Carbon Monoxide Poisoning. U.S. Pub. Health Bull. No. 195, U.S. Government Printing Office, Washington, D. C., 1930, pp. 97.

The literature on the toxicity of carbon monoxide, covering the period of the late 1900's to the late 1920's, is reviewed in this publication. Occurrence, symptoms, methods of detection, the threshold limits, pathology, prevention and treatment of carbon monoxide poisoning are discussed. There is also a short history of the poisonous effect of CO in ancient times, and 195 references. - AGC

933a Six Years of Research in Air Pollution. A Review of Grants-in-Aid, Contracts, and Direct Operations Sponsored by the Division of Air Pollution, Bureau of State Services, July 1, 1955 to June 30, 1961. USDHEW, PHS, Div. of Air Pollution, Washington, D.C., 1961, 290 pp.

This review of 6 yrs. of research in air pollution sponsored by the Div. of Air Pollution, USPHS has been assembled as a narrative summary under the following chapter headings: Engineering research in air pollution; Meteorologic research in air pollution; Chemical research in air pollution; Development of air monitoring; Research in air pollution instrumentation; Bio-medical research in air pollution;

Development of technical assistance; Dissemination of research knowledge. There is also a bibliography of 623 references.

934. The Sixth Annual Air Pollution Medical Research Conference. San Francisco, Jan. 28-29, 1963. Arch. Environ. Health Vol. 8, (Jan.) 1964.

Each year the air pollution conferences have directed concentrated attention to a fundamental problem. This year the problem was the body burden of pollutants. The body burdens of carbon monoxide and of lead have already been used as criteria for air quality.

The acessions on respiratory disease brought together for the first time reports which suggest that chronic pulmonary disease in man has a number of counterparts in experimentally exposed animals. In these experiments, exposure to nitrogen dioxide, adsorbed on activated charcoal, produced destructive alveolar lesions resembling emphysema. Long-term low-level exposures to nitrogen dioxide also can produce changes resembling chronic bronchitis with voluminous lungs. The possibility that immunologic mechanisms are significant in emphysema and the applications of immunologic techniques to the study of asthma due to air pollution also represent a new and promising development in medical research.

Perspectives on the effects of air pollution as well as distinguished scientific reports were presented from Japan and Wales. The findings that chronic respiratory symptoms and impairment of pulmonary function are related in school children to community air pollution exposure represent an important new approach to the study of air pollution effects. The finding that physiologic alterations may occur from experimental exposure to realistic levels of pollutants also is a powerful new discovery.
- AGC

935. Smoking and Health. Report of the Advisory Committee to the Surgeon General of the PHS, USDHEW, PHS, PHSP No. 1103, pp. 344.

The following is a quote from the section "Smoking and Accidents," contained in this comprehensive report.

> "It has been shown that a level of carboxyhemoglobin of 5 percent--a level which is not uncommon among heavy cigarette smokers--depresses visual perception to as great an extent as anoxia at 8,000 to 10,000 feet altitude."

936. Stern, A. C.: Air pollution. Vol. I., Academic Press, N. Y., 1962, 656 pp.

Contents: Pt. 1.--Air pollution and its dispersion. Classification and extent of air pollution problems. L. A. Chambers. Residual pollution products in the atmosphere. B. D. Tebbens. Reactions in the atmosphere.

A. J. Haagen-Smit. Air ions. B. J. Steigerwald. Diffusion and stirring in the lower troposphere. R. C. Wanta. Atmospheric dispersion of stack effluents. G. H. Strom. Pt. II.--The effects of air pollution. Effects of air pollution on materials. J. E. Yocom. Effects of air pollution on visibility. E. Robinson. Effects of air pollution on plants. C. S. Brandt. Effects of air pollution on animals. H. E. Stokinger. Effects of air pollution on humans. J. R. Goldsmith. Pt. III. Measuring and monitoring air pollution.--Air sampling. E. R. Hendrickson. Source testing and monitoring. B. D. Bloomfield. Air analysis. M. B. Jacobs. Production of controlled test atmospheres. J. P. Lodge, Jr. Odor and its measurements. E. R. Kaiser. Meteorological measurements. E. W. Hewson. Automatic instrumentation. N. A. Renzetti. The air pollution survey. A. T. Rossano, Jr. Appendix: Characteristeics of particles and particle dispersoids. Indexes. This book is concerned with the cause, effect, transport, measurement, and control of air pollution. It is intended for professionals, those trained in as wide a variety of callings as are represented among its authors: engineers, chemists, physicists, physicians, meteorologists, lawyers, agronomists, and toxicologists. This is a 2-vol. work, and it may be helpful to the reader who does not find the subject of his interest in vol. I to outline the contents in vol. II. It covers 4 major areas: the emissions to the atmosphere from the principal air pollution sources; the control techniques and equipment used to minimize these emissions; the applicable laws, regulations, and standards; and the administrative and organizational procedures used to administer these laws, regulations, and standards. - APCA 4389

937. Stern, A. C.: Air pollution. Vol. II. Academic Press, New York, 1962, 586 pages.

Contents: Pt. IV.--Air pollution sources. Combustion in furnaces, incinerators, and open fires. R. B. Engdahl. Automotive exhaust emissions. A. H. Rose, Jr. Mineral and metallurgical industry emissions. J. P. Sheedy and C. A. Lindstrom. Manufacture of the major inorganic acids and alkalis. A. N. Heller. Petroleum refinery emissions. H. F. Elkin. Sources of radioactive pollution. M. Eisenbud. Natural sources of air pollution. A. R. Jacobson. Pt. V.--Control methods and equipment. Process and source control. T. Hatch. Efficiency and selection of collectors A. C. Stern. Source control by centrifugal force and gravity. K. J. Kaplan. Source control by filtration. C. Orr, Jr. and J. M. Dalla Valle. Source control by electrical, thermal, and sonic forces. C. F. Gottschlich. Source control by liquid scrubbing. W. E. Ranz. Nuisance abatement by combustion. R. J. Ruff. Source control by solid adsorption. A. Turk. Water pollution potential of air pollution control devices. F. E. Gartrell. Pt. VI,--Air pollution control. Air pollution control administration; planning and zoning. J. J. Schueneman. Air pollution control legislation. S. M. Rogers and S. Edelman. Air pollution standards. A. C. Stern. Source inspection and survey. C. Gruber. Source approval and registration. P. W. Purdom. Public education, cooperation, and voluntary control activities. J. A. Maga. Air pollution personnel. Qualifications and training. E. T. Chanlett. Pt. VII. Air pollution literature resources. J. S. Nader. Appendix I: List of potential air pollution producing industrial uses and operations. II. Petroleum refinery emission and loss factors. - APCA 4458

938. Vol'fson, Z.G.: Limits of allowable concentration of carbon monoxide in atmospheric air. In: Levine, B.S. (translator) and Ryazanov, V.A. (editor): Limits of Allowable Concentrations of Atmospheric Pollutants. U. S. Office of Technical Services, Washington, D. C., Book 1, 1952, pp. 56-64. OTS 59-21173.

The U.S.S.R. literature on studies concerning CO in the atmosphere is reviewed in this paper. Based on clinical and experimental evidence 20-30 mg/m^3 of CO are considered maximum levels at which disturbances in the central nervous system are noticeable. The recommendation for the adoption of standards was made after thorough study of results of investigation and experiments. The population surveyed consisted of children, aged, sick, and generally feeble persons. Following recommendations were made: The maximal allowable limit of average daily CO concentrations in the city atmosphere is not to be above 2 mg/m^3. Maximal single concentration of CO in the atmospheric air must not exceed 6 mg/m^3. - AGC

939. Von Oettingen, W.F.: Carbon Monoxide: Its Hazards and the Mechanism of its Action. Federal Security Agency, U.S. Public Health Service, PHSB No. 290. U.S. Government Printing Office, Washington, D. C., 1944, pp. 257.

Investigations by the author show that CO poisoning is characterized by the formation of CO hemoglobin and that the amount of CO hemoglobin formed depends upon the concentration of CO in the air, the duration of the exposure, and the rate of respiration of the individual exposed. An increase in the temperature, humidity, and CO_2 content of the air or a decrease in the concentration of O_2 will stimulate the respiration and hence favor the absorption of CO. But if such variations are eliminated, certain concentrations of CO in air will convert only a definite percentage of oxyhemoglobin into CO hemoglobin until an equilibrium is reached. The speed with which the maximal concentration is reached depends upon the concentration of CO in air, so that with high concentrations of CO maximal saturation may occur very rapidly.

CO may also react with other "heme"-containing pigments and enzymes, but, of all pigments mentioned, only the pseudohemoglobin has a greater affinity to CO than hemoglobin, and at present it appears impossible to judge on the physiological importance of this phenomenon. The question as to whether or not CO affects the functioning of other pigments such as myoglobin or cytochrome appears to need further study, and the same holds true regarding information on the effect of CO on certain pigments found in the brain.

Regarding the relation between toxic symptoms and the concentration of CO hemoglobin in the blood, it appears that concentrations below 20 percent cause only moderate subjective complaints and that these become serious with concentrations up to 30 percent and alarming with higher concentrations. It appears impossible to state which concentration of CO hemoglobin in the blood will be fatal because this will vary considerably with the type of exposure and the O_2 need of the organism at the time of the exposure, but it appears that concentrations between 60 and 80 percent will be dangerous to life.

Analysis of the clinical picture and the pathological findings in CO poisoning, especially in regard to the behavior of the circulatory apparatus and the central nervous system as well as the metabolism, appears to indicate that the sequelae of CO poisoning are more serious than would be expected from mere anoxemia of a similar degree. In spite of the impressive parallelism between the effects of CO poisoning and those produced by lack of O_2 it cannot be denied that there are a number of reactions and phenomena which may indicate a specific primary or secondary effect of CO on certain "heme"-containing pigments or enzymes of the organism. - Author's Conclusions Modified.

940. White, A. J.: Carbon Monoxide, Your Car and You. Motor Vehicle Research, 1952, pp. 35

This monograph consists of seven chapters. Carbon monoxide and its effects on health is described in Chapters One and Two. Chapter Four discusses the environment in relation to CO, Chapters Five and Six are discussing exposure to CO in garages, its relationship to other exhaust gases and how to reduce CO hazards. How to avoid CO is suggested in the summary. A.G.C.

Legislation

941. Air Pollution. Hearings before a Special Subcommittee on Air and Water Pollution of the Committee on Public Works, United States Senate, 89th Congress, 1st Session on S. 306, April 1965. U. S. Government Printing Office, Washington, D. C., 308 pp.

A Bill to amend the Clean Air Act to require standards for controlling the emission of pollutants from gasoline-powered or diesel-powered vehicles, to establish a Federal air pollution control laboratory, and for other purposes. - AGC

942. Automotive Air Pollution. A Report of the Secretary of Health, Education, and Welfare to the United States Congress Pursuant to Public Law 88-206, the Clean Air Act, 89th Congress, 1st Session, Senate Doc. no. 7 (Jan) 1965. U. S. Government Printing Office, 1965, 22 pp.

By the provisions of a section of the Clean Air Act, the Secretary of Health, Education, and Welfare of the U. S. is to report to the Congress one year after enactment of the section and semiannually thereafter on measures taken toward the resolution of the vehicle exhaust pollution problem and efforts to improve fuels. This report, dated December 1964, discusses current automotive air pollution problems under the headings of: Incidence of photochemical smog; Effects of automotive air pollution; Vehicle use trends; and Recognition by State governments. Progress in the resolution of the problem is considered under the headings of: Exhaust emission control; Crankcase emission control; Fuel evaporation loss control; Maintenance; Fuels; and Diesels. There is a bibliography of 107 references to the current literature. - APCA 65-4

943. Automotive Air Pollution. Second Report of the Secretary of Health, Education, and Welfare to the United States Congress pursuant to Public Law 88-206, the Clean Air Act. Senate Document No. 42. 89th Congress, 1st Session. 1965. 13 pp.

Progress in the reduction of automotive exhaust emissions of hydrocarbons and carbon monoxide is indicated by the scheduled availability of control-equipped vehicles in a limited geographical area late this year and by industry suggestions that similarly equipped vehicles can be supplied nationally in the 1968 model year. Although several of the passenger-car-type exhaust emission control systems have not been fully demonstrated to comply with existing standards (California) regulating hydrocarbon and carbon monoxide emissions, their ability to do so appears to be virtually assured. Knowledge is not available yet, however, regarding the effectiveness of these systems in the reduction of specific organic components of the exhaust nor has it been determined broadly if the performance and durability characteristics are fully consistent with public expectations. The U. S. Public Health Service in cooperation with the General Services Administration is arranging to test the current production-type exhaust emission control systems. General Services Administration has advised that most of the 1966 model vehicles purchased for use by Federal agencies will be equipped with exhaust control systems of the type to be made available in California. The tests will be concerned primarily with the effectiveness of the controls and with variations in their effectiveness associated with geographic and climatic factors. In addition, any effects of the pollution control systems on vehicle performance and maintenance will be evaluated. Of major importance, particularly in relation to the promulgation of national emission control requirements, are ongoing programs of the Public Health Service. Uncontrollable variables are under study and some of their effects have been noted. For example, vehicle operation under low temperature and at high altitudes tends to increase exhaust hydrocarbons and carbon monoxide. That marked additional progress should be forthcoming is indicated by the generally greater interest in other facets of automotive emissions. Diesel emissions, evaporative losses, and fuels effects are being examined more closely both by individual investigators and in group study. Instrumentation and measurement procedures also appear to be receiving greater attention. Other areas of research still appear to require increased emphasis: biological effects, effect of hydrocarbon/nitrogen oxides ratios, reactivity of hydrocarbons, community air monitoring, emission control methods, and effects of engine deposits on emissions. - APCA 65-179

944. Automotive Air Pollution. Third Report of the Secretary of Health, Education, and Welfare to the United States Congress pursuant to Public Law 88-206, The Clean Air Act. Senate Document No. 83, 98th Congress, 2nd Session, 1966, 13 pp.

Reduced exhaust emissions of hydrocarbons and carbon monoxide have become a reality in California with the introduction of the 1966-model passenger cars and light commercial vehicles. Recognition of the need for still further control measures is evidenced by the adoption of nitrogen oxide standards by the California Board of Health.

The Department of Health, Education, and Welfare is implementing the new responsibilities and authorities conferred by the Motor Vehicle Air Pollution Control Act. Standards for the control of emissions from gasoline-fueled vehicles are being developed accordingly, to become effective with the 1968 models.

Some additional technical information has become available. Further studies of the effect of ambient temperature on exhaust emissions indicate that low temperatures tend to increase exhaust hydrocarbons and carbon monoxide, particularly following cold-engine starts. Preliminary results obtained from a study of the effect of leaded fuels indicate that combustion chamber deposits may not significantly affect the quantities of hydrocarbons and carbon monoxide emitted in exhaust gases. A survey being conducted to measure carbon monoxide levels in urban communities suggests that human exposure to carbon monoxide may be greater than routine atmospheric monitoring data had indicated.

A number of new projects are being initiated by the Government to study the performance characteristics of production-type exhaust emission controls in varied environments, to develop more definitive data on exhaust emissions from small cars and diesel-powered vehicles, to learn more about human tolerance of lead and carbon monoxide, and to effect control of oxides of nitrogen. An expansion of industry research in automotive air pollution and its control is indicated by the recent activities of technical associations.

945. Caplan, J.D.: Causes and control of automotive emissions. In: Air Pollution Control. Hearings before a Special Subcommittee on Air and Water Pollution of the Committee on Public Works, United States Senate, 89th Congress, 1st Session on S 306, April 1965, U. S. Government Printing Office, Washington, D. C., pp. 160-171.

The sources and composition of emissions from gasoline-engine vehicles are described, the causes are elucidated, and the importance of specific components of the emissions is discussed. Methods of reducing the emissions from the various sources are presented along with an evaluation of their respective merits and limitations. In addition, the need for additional research concerning the importance of specific emission components is explained. Finally, the Automobile Manufacturers Association's co-operative programme for vehicle emission control is discussed. - Author's Abst.

946. Clarkson, D., and Middleton, J.T.: The California control program for motor vehicle created air pollution. J.APCA 12:22-28 (Jan.) 1962.

California was assigned a new role in the battle against air pollution in 1960 when legislation was enacted which established the Motor Vehicle Pollution Control Board and a program to control air pollution created by the motor vehicle. The legislation extended the State's role in air pollution control beyond its traditional one of research and assistance to local governmental agencies to one of direct control. The State thus is now responsible for controlling moving sources of pollution while local agencies retain their long-standing responsibility for control of stationary industrial and domestic pollutors. Whereas local agencies have instituted programs designed to control the stationary sources which vary in number, kind, and importance as pollutors in various areas of California, a technically sound and administratively feasible program of control of vehicular emissions can be achieved only by the state level of government. Uniformity in the requirements for control throughout the State is necessary because of the mobility of motor vehicles without regard to local political boundaries and because they are an air pollution factor common to all densely populated areas of the State. A State program insures equitability in the application of control requirements and ease of administration.

This paper discusses the program instituted by the Motor Vehicle Pollution Control Board, which represents a first attempt to control air pollution created by motor vehicles, an essential step to achieve satisfactory air quality throughout California. -Authors' introduction -AGC

947. The Clean Air Act December 17, 1963 - Public Law 88-206. As Amended October 20, 1965 - Public Law 89-272. U. S. Department of Health, Education, and Welfare; Public Health Service; Washington, D. C. 20201, 1965, 14 pp.

This is the legal statement of the Clean Air Act of 1963 as amended, on October 20, 1965, to become Public Law 89-272. - APCA 65-185

948. Comparison of National Laws and Regulations; Possibility of Standardizing These and Drawing up Technical and Legislative Agreements and European Conventions on Air Pollution. (General Report) European Conference on Air Pollution, June 24-July 1, 1964. Council of Europe, Strasbourg, (France), 1964, 12 pp.

This General Report, published following the European Conference on Air Pollution, is presented by Professor Högger, University of Zurich, who is Chairman of the Commission Fédérale de l'Hygiène de l'Air. The table of contents lists the following subject headings: Dangers, inconvenience, and damage caused by air pollution; Remedies; General principles of legislation (prohibition of unpleasant and dangerous emissions, limitation of emissions); How far should clean air requirements go?; Special provisions (industry, domestic fires, motor vehicles); Application of regulations; European cooperation; Conclusions; and an Appendix in which are outlined several points to be settled in national legislation according to the conditions in each country, relating to domestic fires, industry, motor vehicles, and sanctions and controls. - APCA 64-248

949. A Compilation of Selected Air Pollution Emission Control Regulations and Ordinances. Tech. Rep. A65-34. U.S. PHS, Cincinnati, Ohio, May 11, 1965, 123 pp.

The introduction states that this compilation contains selected sections of many emission control regulations and ordinances. It has been prepared to provide state and local air pollution control agencies, industries, and other interested people with selected examples of the many types of regulations and ordinances in use today. All sections of regulations and ordinances included have been copied directly from the original text of individual state and local laws. The regulations and ordinances have been arranged in such a manner that each section of this report is a compilation of laws pertaining to a specific type of pollutant or pollutant source. These sections include Smoke Emissions and Equivalent Opacity Regulations, Regulations Pertaining to Particulate Emissions from Fuel Burning Plants, Regulations Pertaining to Particulate Emissions from Refuse-Burning Equipment, Regulations Pertaining to Particulate Emissions from Manufacturing Processes, Regulations Pertaining to Sulfur Compound Emission Control, Regulations Pertaining to Hydrocarbon Emission Control, Regulations Pertaining to Fluoride Emission Control, Regulations Pertaining to Motor Vehicle Emission Control, Regulations Pertaining to Odor Emission Control, and Zoning Ordinances. The regulations and ordinances compiled were selected to represent the different methods of controlling emissions by law and to represent varying degrees of control. The definitions used were for the most part taken directly from existing regulations and ordinances. Some were picked selectively to provide what were felt to be very good definitions while others were picked because of their wide use by many states and communities. - APCA 65-73

950. Control of air pollution from motor vehicles and new motor vehicle engines. Proposed Rules. Federal Register Part II, 30:17192-17199 (Dec. 31) 1965.

The maximum allowable rates for discharge of two major automotive air pollutants are similar to standards adopted by California for 1966, and provide: 1. Vehicles with engine displacement of 140 cu. in. or less: (a) hydrocarbons - 375 ppm as hexane (0.165 mole percent carbon atoms) and (b) carbon monoxide - 2.0% by volume. 2. Vehicles with engine displacement in excess of 140 cu. in.: (a) hydrocarbons - 275 ppm as hexane (0.165 mole percent carbon atoms) and (b) carbon monoxide - 1.5% by volume.

The average car without an exhaust control system emits approximately 800 ppm of hydrocarbons and 3.5% carbon monoxide from its exhaust.

In addition to limiting exhaust emissions, the standards are designed to eliminate complete hydrocarbon emissions from the crankcase. - AGC

951. Control of air pollution from motor vehicles and new motor vehicle engines. Federal Register Part II, 31:5170-5178 (March 30) 1966.

Federal standards for the control of air pollution from new motor vehicles were published today in the Federal Register by Secretary of Health, Education, and Welfare John W. Gardner. The standards will apply to 1968 model gasoline-powered passenger cars and light trucks, whether American-made or imported.

The standards, issued under provisions of the 1965 Clean Air Act Amendments, will limit emissions of two major pollutants produced by motor vehicles--hydrocarbons and carbon monoxide. Hydrocarbons are a prime ingredient in the formation of photochemical smog. Carbon monoxide is a lethal gas.

Under the standards proposed on December 31, tailpipe emissions from motor vehicles with engines of 50 to 140 cubic inches cylinder displacement would have been limited to an average of 375 parts per million of hydrocarbons and 2.0 percent carbon monoxide over a vehicle life of 100,000 miles. Engines of more than 140 cubic inches, which produce a greater volume of exhaust gas, would have been limited to an average of 275 parts per million of hydrocarbons and 1.5 percent carbon monoxide.

The final standards call for no change in the limitations on engines in the over-140 cubic inches size range, but significant modifications have been made in the requirements applicable to smaller engines. These have now been placed in two separate categories. For those of 50 to 100 cubic inches cylinder displacement, which include the engines used in most small imported cars, the limitations are now an average of 410 parts per million of hydrocarbons and 2.3 percent carbon monoxide. For engines of 100 to 140 cubic inches, the limitations are an average of 350 parts per million of hydrocarbons and 2.0 percent carbon monoxide.

952. Lawther, P.J.: Air Pollution. Bull. New York Acad. Med. 41:214-216 (Feb.) 1965.

Following the Beaver report and the pollution control activities which came about following the passage of the Clean Air Act of 1956, smoke is slowly disappearing from the air of Britain but other pollutants are left, notably SO_2. Pollution in Britain is due overwhelmingly to the combustion--both complete and incomplete--of coal and oil, much of which contains compounds of sulfur as impurities. The commonest pollutant, CO_2, is accepted as innocuous; smoke (from incomplete combustion) and SO_2 are measured routinely and are used as indices of pollution. These 2 pollutants vary widely in concentration and are present in roughly the same amounts in New York and London. It is well that in neither city does the topography and climate favor the formation to any significant extent of the photochemical haze which plagues the citizens of Los Angeles, especially since CO from motor vehicle exhausts has been found at levels as high as 360 ppm. on the pavement at Oxford Circus in London. After much hard work it can be said with a degree of certainty that high concentrations of urban pollution, measured in terms of SO_2 and smoke, aggravate existing chronic nonspecific pulmonary disease and may prove to be an intolerable stress to those in a community who are aged or suffering from severe illness. The implementation of the Clean Air Act has radically altered the smoke/SO_2 ratio and it is hoped that it may now be possible to distinguish between the effects of these 2 main pollutants. Studies of daily variations in morbidity and mortality undertaken in London and New York City (which is low in smoke content of the air) may add much to the knowledge of these 2 pollutants. Laboratory findings of sensitivity to SO_2 and the response of the individual to varying pollution levels, often do not correlate well. Air pollution is, of course, still suspect as an etiological factor in the production of chronic bronchitis but it will be hard to indict it with certainty since it is but 1 of many noxious factors in urban life. Current work would lead to the belief that "classic" carcinogens, such as 3,4-benzpyrene, may have claimed too much attention in recent yrs. to the detriment of the search for more sophisticated mechanisms by which lung cancer may develop. The manner in which

asbestos produces neoplasms may have much to teach us with respect to the wider problems of carcinogenesis. - APCA 6773

953. MacKenzie, V.G., and Flieger, K.: The Clean Air Act. Amendment and Solid Waste Disposal Act of 1965 (P.L. 89-272). HEW Indicators, Nov. 1965, pp. 17-29.

With the signing by President Johnson on Oct. 20, 1965, P.L. 89-272, the Federal Government assumed major new responsibilities for the prevention and control of air pollution. This legislation amends the Clean Air Act of 1963 (P.L.88-206) by giving the Secretary of Health, Education and Welfare authority to: (1) control air pollution from new motor vehicles; (2) take action to abate air pollution which originates in the U.S. and endangers the health or welfare of persons in neighboring countries; (3) investigate and seek to prevent new sources of air pollution from coming into being; (4) construct, staff, and equip facilities needed by the Dept. to carry out its increased responsibilities under the amended Clean Air Act. The President's signature also brought into being the Solid Waste Disposal Act, which authorizes the Dept. of Health, Education, and Welfare and the Dept. of the Interior to invest more than $92 million over the next 4 yrs. in research and development activities, demonstration projects surveys, technical and financial aid to State, regional, and local agencies to assist in the planning, development and conduct of solid waste disposal programs. This paper discusses the history of the legislation and various features of the Act. - APCA

954. Motor Vehicles, Air Pollution, and Health. Part I. Summary - A Review of the Problem. II. Effects of Motor Vehicle Pollution on Health. III. Air Pollution from Motor Vehicles. A Report of Surgeon General to the U.S. Congress in compliance with Public Law 86-498, The Schenck Act, June 1962. USDHEW, U.S. Government Printing Office, Washington, D.C., 1962, pp. 112-125.

Contained in this comprehensive report, which is the result of two years intensive research conducted by the Division of Air Pollution, is a section on CO, discussing the environmental levels; contribution of automotive emissions; the effect on health including a review of studies on the toxicology of CO and chronic CO poisoning; experimental studies on man and animal; and a survey of traffic exposed persons. - AGC

955. Status report on cost factors in exhaust control. TA-10 Vehicular Exhaust Committee (Jansen, D., Chairman). J. APCA 14:427-429 (Oct.) 1964.

The problems of controlling automotive exhaust and of estimating costs are exceedingly complex. Questions still exist as to the actual level of emissions and the degree of controls required. As yet, no exhaust device or control system is in production.

This report, published as Informative Report No. 5 of the Air Pollution Control Association's TA-10 Vehicular Exhaust Committee, began to move through the fourteen-step approval procedure on March 25, 1964. Comments made by members of the Technical Council were used in the preparation of the final report. It is now published as representing the "best thinking of the Association." It is an extremely timely and formative report. - Authors' Abst. Modified.

Review Papers

956. Altshuller, A.P.: Air pollution. Anal. Chem. 37:11-20 (April) 1965.

The work covered in this review was presented or published between 1962-64. Methods of analysis for inorganic and organic pollutants in urban atmospheres are of interest and the greater amount of work has been toward analyses for inorganic sulfur compounds, oxidants, C_1-C_{10} hydrocarbons, and polycyclic hydrocarbons. A wide variety of biological substrates are being used to detect air pollutants in the laboratory. Plants, particularly varieties of tobacco wrapper, petunia, and pinto bean are used in both laboratory and field. Photosynthesis morphological or biochemical changes in bacterial cultures, immobilization of paramecium, inhibition of cell growth in vitro, and human eye irritation have been used as indicators of various pollutants. Sampling and calibration methods, particulates and aerosols, organic particulate, inorganic gases, carbon monoxide and carbon dioxide, sulfur dioxide and sulfur trioxide, hydrogen sulfide, nitrogen oxides, ozone and oxidants, fluorides, organic gases and vapors, atmospheric reactions, and analyses of sources of pollutants are discussed. Field studies and results are also discussed. 305 references. - APCA 6724

957. Baetjer, A.M.: Chronic exposures to air pollutants and acute infectious respiratory diseases. Arch. Indust. Hyg. & Occupat. Med. 2:400-406 (Oct.) 1950.

Data in this review, obtained from studies of the health of persons who had been exposed to specific chemical contaminants of the air have not yielded any definite evidence that chronic inhalation of such chemical contaminants in low concentrations affects susceptibility to acute infections of the respiratory tract. Author states that the data available at present are entirely insufficient to enable one to draw any definite conclusions, and suggests further fundamental research along the following four subjects: 1. Basic studies on the physiologic effects of air pollutants on the body tissues; 2. animal experimentation on the effects of these substances on susceptibility to infectious diseases; 3. industrial morbidity studies in relation to known exposures and 4. well controlled epidemiologic studies. Not until such data become available can any positive statement be made concerning the effects of chronic inhalation of atmospheric contaminants on acute infections of the respiratory tract. - Author's Conclusions Modified - AGC

958. Breysse, P.A.: Chronic carbon monoxide poisoning. Indust. Med. & Surg. 30:20-22 (Jan.) 1961.

Author summarizes this review of eleven papers with the following: "Some of the attitudes that have been encountered are reflected in this review. At once it becomes apparent in some instances that what has been termed chronic carbon monoxide poisoning is not other than repeated episodes of acute poisoning. This indicates chronic exposure rather than chronic poisoning. Other situations that have been characterized as chronic poisoning relate to the well-known sequelae that sometimes follow severe acute poisoning. Notwithstanding, there is warrant to iterate the statement contained in the 1930 International Labor Office publication: The question of the existence or not of chronic CO poisoning has been much discussed and is not yet settled." - quoted from text-AGC

959. Caplan, J.D.: The automobile manufacturers vehicle emissions research program. J.APCA 13:105-108 (March) 1963

The broad program of the AMA is outlined and discussed. AMA remains in close contact with the U.S. PHS and the California authorities. -AGC.

960. Carbon monoxide poisoning and the automobile exhaust. From the review of literature by the Special Sub-committee of the Committee on Public Health Relations. Bull. New York Acad. Med. 2:402 (Aug.) 1926.

Carbon monoxide poisoning is closely related to the history of mankind. Carbon monoxide is so dangerous because it is colorless, tasteless, and practically odorless. The weight of opinion favors carbon monoxide as causing anoxemia, which, in turn, causes death. Clinical symptoms, both acute and chronic, are reviewed. The individual's idiosyncrasy will determine whether he will receive permanent damage from carbon monoxide or none at all. Tolerance or immunity to carbon monoxide will protect some from large amounts of the gas, and yet others will be overcome by the same amount of carbon monoxide gas.

Effects of the gas have been noted by traffic officers on busy Chicago street corners. All writers appear to agree that slow, gradual gassing is far more serious to a man than to be suddenly exposed to a high concentration. In gasoline engines there will be from 2-13 percent, or even higher, of carbon monoxide in the exhaust. Carbon monoxide density is practically the same as air density. The composition of exhaust gas is tabulated. Carbon monoxide from car exhaust lies in a layer about 5 to 15 feet above the street, and the concentration depends upon atmospheric conditions. On damp, still days the carbon monoxide content of the street mounts during heavy traffic to a point where a distinct health menace is created. Some writers accredit some accidents to the mental dullness of drivers due to carbon monoxide. Headache, dizziness and reduced vision and coordination are common complaints of motorists in a slow moving line of traffic. Traffic police report fatigue, dryness in the throat, headaches and bronchial irritation after directing traffic at a busy intersection. - BAAP 168

961. Carbon Monoxide: Its Toxicity and Potential Dangers. Pub. Health Rep. 56:421-433 (March 7) 1941.

Author, in reviewing the pertaining literature, describes sources of exposure to CO in industrial enterprizes and exposure of workers to CO in these industries. Methods of sampling and the determination of CO concentrations under various conditions, methods to determine CO in blood and the relation between concentrations of CO in air and toxic systems, as well as the physiological response to various concentrations of CO are discussed. Measures for the prevention of CO poisoning are outlined.

The maximal permissible concentration of CO in air is accepted as 100 parts per million or 0.01 percent by volume (0.11 mg per liter at 25° C. and 760 mm. Hg.) for exposures not exceeding a total of 8 hours per day, and as 400 ppm or 0.04% by volume (0.46 mg. per liter at 25° C. and 760 mm Hg.) for exposures not exceeding a total of 1 hour daily. - AGC

962. Castellino, N., and Perla, V.: Carbon monoxide concentration in the blood. Folia Med. 42:209-222 (March) 1959.

Blood concentrations of carbon monoxide was measured in 302 patients: 46 with diabetes, 66 with gastrointestinal and hepatic disturbances, 38 with anemia, 30 with cardiac conditions, 74 with respiratory ailments, and in a group of patients with occupational diseases: 24 with caisson disease and 14 with lead poisoning. The readings were compared with those obtained from 100 normal subjects. In only a very few patients with uncompensated cardiocirculatory disturbances or respiratory diseases was any increase in the hematic CO level noted. The high concentration in these particular morbose conditions is attributed to incomplete CO elimination through the lungs, with a consequent build-up in the blood, rather than, as others have argued, to oxygen insufficiency, with a consequent failure to oxidize carbon to carbohydrate. Hence the presence of CO in the human bloodstream must be considered as of foreign origin. The wide variations observed, under normal as well as pathological conditions, simply reflect heavier absorption or a lowered elimination rate as a result of individual or environmental differences. - Authors' Sum.

963. Chronic carbon monoxide poisoning. New Engl. J. Med. 261:1248-1249 (Dec. 10) 1959.

In this review it is noted that carbon monoxide poisoning in the acute form has long been recognized but that the slower and more insidious form of intoxication, with intermittent symptoms and vague relations to the sources of poisoned atmosphere, is only now being brought into prominence. The basic facts were mostly gathered in Europe and about 10 years ago were published in a Danish monograph by Grut (Copenhagen, Ejnar Munksgaard, 1949). Recently the subject has been activated with reports from health authorities in the state of Connecticut. Carbon monoxide poisoning in a chronic form, because of psychiatric and neurologic symptomatology, is frequently incorrectly diagnosed as epilepsy. It is possible that some people are more susceptible to this form of attack than are others, but the timing of attacks, their nature, the mental changes, and the intermittent symptoms should lead to a diagnosis in all persons exposed to carbon monoxide whether inside or out-of-doors. - APCA 3949

964. Clemens, J.B., and Thompson, W.G.: Carbon monoxide poisoning and the automobile exhaust. Review of literature by the Special Sub-Committee of the Committee on Public Health Relations. Bull. New York Acad. Med., pp. 402-440, 1926.

The literature on effects of carbon monoxide on health, in garages and repair shops, the chemical properties of exhaust gas and smoke, is reviewed in this paper. The different opinions expressed as to the basic nature of the problem have been noted. One group maintained that the poisonous manifestations of the gas are due solely to oxygen deprivation caused by the affinity of CO for hemoglobin, while another group holds that the gas has a specific toxic action on the nerve tissues and cells. Further studies to reduce CO content in exhaust gases and frequent exposure to very low concentrations of CO in the inspired air and its effect upon the human system are recommended. - AGC

965. Ehrich, W.E., Bellet, S., and Lewey, F.H.: Cardiac changes from CO poisoning. Amer. J. Med. Sc. 208:511-523, 1944.

All experiments were performed upon dogs. Acute CO poisoning was produced in some animals by inhalation of the gas and in others by intravenous introduction of erythrocytes saturated with CO; while chronic poisoning was effected by exposure to 0.01 vol. % CO for 5 3/4 hours daily over a period of 11 weeks. As a control, chronic anoxia was produced in other animals by exposure to an atmosphere containing only 10 vol. % O_2.

The electrocardiographic changes observed were inversion of the T wave, elevation of the R-T segment, atrioventricular dissociation, and A-V heart block. The morphologic changes included certain degenerative changes of individual muscle fibers, as well as hemorrhages and necroses of the myocardium. While the changes in the T wave and R-T segment and the degenerative changes appeared as early as at 40% COHb in acute experiments, or at 21% COHb or an equivalent O_2 deficiency in chronic exposure, heart block and myocardial hemorrhages and necroses were observed only when the COHb level exceeded 75% for 1 hour or longer.

It was noted that the electrocardiographic and morphologic changes of the heart in CO poisoning closely resemble those observed in anoxia due to other causes. Authors also give a brief review of the literature on cardiac changes. - Authors' Sum.

966. **Engstedt, L.: Endogenous Formation of Carbon Monoxide in Hemolytic Disease. With Special Regard to Quantitative Comparisons to Other Hemolytic Indices. Acta Medica Scandinavica, Vol. 159, Suppl. 332, pp. 61, 1957.**

During the last fifteen years the knowledge of erythrocyte and hemoglobin catabolism has rapidly increased. New isotope techniques have been useful tools, but other methods, for instance the old principle of differential agglutination of transfused erythrocytes, have also contributed to a great extent.

Bile pigments have long been known as end products of hemoglobin catabolism, and they have been used as an index of erythrocyte breakdown. A few years ago it was shown that there is a continuous formation of small amounts of carbon monoxide in man and that at least the greatest part of the exhaled carbon monoxide is formed during the break-down of hemoglobin. The formation of carbon monoxide during hemoglobin catabolism was also confirmed by studies in vitro.

However, it is not known to what extent carbon monoxide formation gives a quantitative estimation of hemoglobin break-down in clinical cases with increased hemolysis, or if increased carbon monoxide formation is a constant finding in such cases. "Erythrokinetic" studies have been done with various other methods, but determinations of carbon monoxide production have not been utilized for such investigation.

The present paper deals with quantitative comparisons between carbon monoxide formation and some other indices of hemoglobin break-down, and besides an evaluation of the practical value of the carbon monoxide method is made. - Author's Introduction

967. Fisher, M.B.: A summary of previous carbon monoxide studies. In: Conference Proc.: Health, Medical and Drug Factors in Highway Safety. Second Highway Safety Research Correlation Conference, April 5 & 6, 1954, Washington, D. C. Nat. Acad. Sc.-Nat. Res. Council Pub. 328, Sept. 1954, pp. 4.1-4.6.

Author relates the generally accepted physiological description of carbon monoxide poisoning, which basically is a process of anoxemia. The hemoglobin of the blood can take up either oxygen or carbon monoxide or a number of other materials. The problem arises because hemoglobin has a much greater affinity for CO than for oxygen. The ratio of these affinities is of the order of 210 to 1 with the result if there is any CO present in the atmosphere it will be taken up by the hemoglobin. Author states that the extent of variability in human behavior in response to various levels of CO in the atmosphere and to various levels of COHb in the blood as well as chronic CO poisoning needs further investigation. - AGC

968. Frederick, R.C.: Carbon monoxide poisoning: Its detection, and the determination of percentage saturation in blood, by means of the Hartridge Reversion Spectroscope. Analyst 56:561-568 (Sept.) 1931.

The history of CO poisoning is briefly reviewed. Physiological responses to various concentrations of CO as studied and summarized by earlier investigators are shown in tables. The application of the Hartridge Reversion Spectroscope which is a reliable tool for the detection of small amounts of CO in the blood is described in detail. - AGC

969. Gramer, L.: Various methods for the determination of CO in blood. Das Ärztliche Laboratoriem Heft 12, pp. 373-380, 1961.

Author states that because a margin of errors are possible in all methods to determine CO in blood, that at least two different methods should be employed for each test. The following five methods are described in detail: 1. The manual spectroscopic test which is a qualitative analysis showing positive only from 26% CO-Hb. 2. Quantitative reaction method according to Wolff, giving sufficiently correct results if instructions are rigidly followed. 3. Roughton and Scholander's microgas analysis, which was found very useful. 4. The turbidimetric method developed by the author, the appliance of which is easy and simple and sufficiently correct. 5. There is only a short comment on the Grosskopf and Sachs method since an extensive review was published in the "Dräger Hefte" No. 235, Oct. 1958/March 1959. - From German-AGC

970. Hayashi, S.: Present situation of the control of public hazards in Japan. Kuki Seijo (Tokyo) 1:8-12 (March) 1964.

Accompanying the rapid economic growth of Japan since 1959, there has been the establishment of 19 public agencies for the control of hazardous environmental conditions. Previous to this time there were only 2 such agencies. In this review are discussed various legislative measures, some statistics on the number of hazardous happenings during the years 1962 and 1963, and some of the kinds of public hazards. Among the latter are enumerated noise, water pollution, mining dust and gases, agricultural chemicals, dust pollution, and vibration. The amounts of deposited soot, measured mainly in 1961, at various places in Japan are tabulated. The maximum was 137 tons/km.^{2}/month at Wakamatsu. At Kamaishi it was 116 tons/km.^{2}/month and at Yahata it was 113 tons/km.^{2}/month. The maximum amount of SO_2, expressed as SO_3, was 6.44 mg./100 cm.^{2}/day at Kawasaki. The amount of CO and NO_2 in car exhaust gases, in the air of some large cities reached values of 10-20 ppm. and 0.02-0.05

ppm., respectively. The general trend of air pollution is that the amount of deposited soot is decreasing while the amount of SO_2 is increasing; the amount of suspended dust is remaining constant. - APCA 6417

970a. Hellmann, C.S.: Initial Survey of Published Work in the Field of Carbon Monoxide or Other Diatomic Molecular Gases with Particular Reference to Possible Sensing Systems. Douglas Aircraft Co., Inc., Calif., Sept. 25, 1961, 1961, 75 pp. DDC AD 277157.

The provision of a carbon monoxide sensor as a novel and necessary new item of research equipment is discussed. Primary emphasis is placed on possible means of achieving a practical sensor design; appendices include the basic derivations and terminology peculiar to the fields of chemical and molecular physics, with accent on molecular spectrography.

Bio-physical aspects and other possible uses are noted. A complete table of constants as a possible design basis is included in the main text and amplified in the appendices. - Author's Abst.

971. Hurtado, A., Merino, C., and Delgado, E.: Influence of anoxemia on the hemopoietic activity. Arch. Internat. Med. 75:284-323, 1945.

The investigations to be reported in this paper concern the morphologic and other characteristics of the circulating blood under the influence of temporary, intermittent and chronic anoxic anoxia (anoxemia). Most of the work has been carried out at high altitudes and the results obtained have been compared with those observed in the study of healthy subjects at sea level and in previous related investigations. No attempt has been made to cover all the vast literature accumulated in this field. - Authors' Abst.

972. Larsen, R.I.: Motor vehicle emissions and their effects. Pub. Health Rep. 77:963-969 (Nov.) 1962.

The findings from current research, on quantities and types of air pollutants from motor vehicles and the effects of these pollutants on the health of man, plants, and laboratory animals, are briefly summarized from papers given at 2 conferences held in Los Angeles in Dec. 1961. The 5th Air Poll. Med. Research Conference, on Dec. 4, was sponsored by the Calif. State Dept. of Health. The Joint Research Conference on Motor Vehicle Emissions and Their Effects, on Dec. 5-7, was sponsored by the Calif. State Dept. of Health and the Public Health Service's Div. of Air Poll. The information is given under the subject headings of atmospheric reactions, carbon monoxide, eye irritation, lung effects, plant damage, effects on laboratory animals, air quality standards, and vehicle exhaust control. Copies of some of the conference papers are available from Dr. John R. Goldsmith, Head, Air Poll. Med. Studies, Calif. Dept. of Public Health, Berkeley 4, Calif. -APCA 5051

973. Lilienthal, J.L., Jr.: Carbon monoxide. Pharmacol. Rev. 2:324-354 (Aug.) 1950.

In the recent years steady progress has been made in filling in the details of well-grounded concepts of the action of CO; and newer observations have led into unexpected developments. A wide spectrum of biological processes not dependent on hemoglobin have been found to be impaired by CO. Skeletal and cardiac muscle, and the intact animal as well, have been shown clearly to possess the capacity of oxidizing CO to CO_2. The basic relations of CO, O_2 and Hb both in static and dynamic systems have been explored with profitable clarification of the fundamentals. More precise measurements are available now to define those factors which modify the rate of uptake and elimination of CO in man. The higher resolution of technics for assessing function in man have provided evidence of the impairment produced by small amounts of CO. The phenomena associated with acclimatization have been under study but the mechanisms are unexplained. A large number of special systems are altered by exposure to CO, but in many it is not clear yet whether these effects are specific for CO or rather simply general reactions to any restriction in the normal delivery of O_2 to tissues. Therapy available for CO poisoning is based primarily on the fundamental relations of CO, O_2 and Hb.

This report is a review of the world literature of the last 60 years and discusses following topics: Analytical Methods. Effects of CO Not Mediated by its Action on Hemoglobin. Metabolism. Uptake and Elimination of CO in Man. General Symptomatology. Tolerance and Acclimatization. Respiratory and Circulatory Effects. Peripheral and Central Neural Effects, and Special Effects of CO. There are 234 references. - Author's Sum.-AGC

974. Luther, H.: Research problem: Exhaust gas. ATZ (Automobiltechnische Zeitung) 62:326-328 (Dec.) 1960.

This article is a survey of the status of research and development in the abatement of injurious pollutants from the exhaust gas of internal combustion engines. Several research groups in Germany, currently engaged in this endeavor, are cited. Chemical modification of exhaust gas composition (e.g. carbon monoxide), physiological effect of exhaust gases and testing of proposed methods of the modification of engine exhaust gases are reviewed. - AGC

975. Pfrender, R.E.: Chronic carbon monoxide poisoning. A critical resume. Indust. Med. & Surg. 31:99-103 (March) 1962.

Author discusses CO combinations with other substances, pathological effects attributable to CO per se, and the nature and extent of acceleration to the gas. Pertaining literature is also reviewed. -From author's sum. -AGC.

976. Polluted air linked anew to disease. AMA News, Oct. 30, 1961.

This editorial discusses three scientific reports linking polluted air with cardiac and respiratory diseases. A survey in Los Angeles showed that motor vehicles are the major sources of air pollution. An analysis of air contaminants in Los Angeles showed that each day 965 tons of hydrocarbons, 250 tons of NO, 19 tons of SO_2, 6850 tons of CO, and 27 tons of aerosols are released from motor vehicles alone. The first device for reducing smog producing hydrocarbon emissions from motor vehicles has been accepted. This device is a "positive crankcase ventilation system," and said to eliminate a third of the pollutants in the blowby gases from the crankcase. It does not reduce exhaust emissions. Nine devices to cut exhaust emissions are currently being studied. -AGC.

977. Report on diesel smoke. Information Report No. 2. (Vehicular Exhaust Committee, Chairman: Jensen, D.A.) J. APCA 13:290-291 (June) 1963.

The purpose of this report is to present a summary of factors that influence the production of exhaust smoke in diesel engines. Also provided is information relating to known methods for reducing or eliminating diesel smoke. It is, in effect, a report on the current state of the art in the area of diesel smoke and is intended to be used as a supplement to the results of the laboratory research being carried on to determine the chemical composition of diesel engine exhaust.

Included in this report are discussions of diesel fuel properties, engine adjustment and maintenance procedures, engine operation and driver procedures, and features of engine devices. All of these items have an important bearing on the smoke properties of diesel engines installed in motor vehicles. - Author's Introduction

978. Rowan, T., and Coleman, F.C.: Carbon monoxide poisoning. Review of the literature and presentation of a case. J. Forensic Sc. 7: 103-130 (Jan.) 1962.

A case of carbon monoxide poisoning is presented which illustrates some of the difficulties encountered in assessing the severity of poisoning, especially where compensation is a factor. The literature is reviewed to demonstrate the protean manifestations that may be found. Blood samples should be taken from patients as soon as possible where the possibility of CO poisoning exists and if possible, a sample of the supposedly vitiated atmosphere. - Authors' Sum.

979. Ryazanov, V.A.: New data on limits of allowable atmospheric air pollutants. In: Levine, B.S. (translator and editor): U.S.S.R. Literature on Air Pollution and Related Occupational Diseases. A Survey. U.S. Dept. of Commerce, OTS 64-11574, Washington, D. C., Vol. 9, 1964, pp. 1-8.

This is a review of papers presented at the Meetings of the Committee on Sanitary Air Protection in 1959 and 1960. The air pollution standards under discussion and the conclusion reached are not to be considered as final. The aim and purpose of the Committee is to stimulate research. In the section on carbon monoxide the papers by L.S. Gorsheleva, and T.M. Shul'ga, are discussed. Animals exposed for six hours to air containing 20-30 mg/m^3 of CO disturbed the conditioned reflexes activity. The Committee adopted 1/10 of this concentration, or 2 mg/m^3 as the MAC average for 24 hours, or three times the average of 24-hour concentration as the maximal allowable single concentration of CO.

The paper by Shul'ga discusses the previously adopted limit of concentration of 6 mg/m^3 of CO in accordance with the definition of a maximal single concentration. The electroencephalographic method which is considered to be most sensitive was used. Results show that 20 mg/m^3 CO had no effect on the reflex reaction of brain biocurrents either directly or through the formation of conditioned electrocardial reflexes. Tested on humans, the maximal allowable single concentration for CO as accepted by the Committee, when inhaled for a brief period of time, had no effect on the human organism. The Committee in regard to Shul'ga's recommendations lowered the average 24-hour concentration limit to 1 mg/m^3, retaining the previously adopted 6 mg/m^3 value as the limit of allowable single CO concentration. - AGC

980. Shumway, E.A.: Chronic carbon monoxide poisoning an increasing danger to municipalities from automobile traffic. Med. J. & Record 121:657-659 (June) 1925.

This paper reviews and discusses the literature on CO and as author states serves to impress upon the general practitioner the importance of going into the living conditions of his patients, and making inquiries as to the possibility of chronic poisoning by carbon monoxide in those suffering from headache, gastrointestinal disturbances, anemia, lowered nutrition and neurasthenia. - Author's Sum.

981. Smith, C.: Therapeutic applications of oxygen at two atmospheres pressure. Dis. Chest 45:15-23 (Jan.) 1964.

Author describes in the paragraph on CO animal studies of anoxia. The results obtained indicated that two atmospheres pressure of oxygen were enough to dissolve in the plasma and to correct the anoxia immediately. - AGC

982. Tope, O.: Health effects from exhaust with consideration of special vehicles and motorized equipment. Städtehygiene. 2/1965.

The noxious components of exhausts from combustion engines are discussed in this paper. Author states that the most dangerous component, the carbon monoxide, causes already in low concentrations symptoms of poisoning. The maximal allowable concentration for carbon monoxide is about 0.01 percent per volume, however repeated concentrations below 0.01% cause pathogenic symptoms. Literature review shows that small amounts of CO may cause chronic poisoning. One investigator established that very low CO concentrations lower the physical and mental capacities of animals. The effect of CO is quite treacherous because symptoms of acute poisoning appear only when a considerable percent of hemoglobin has been changed to carboxyhemoglobin. This leads to disturbance of the orientation and judgment ability in drivers, and driver may fall asleep while driving. Also, the ability to see is impeded, content of the exhaust gas depends very much on the condition of the engine. Author recommends a revision of the construction of combustion engines and the application of electric energy in order to eliminate the potential danger of auto exhaust. -AGC.

983. Wechsler, I.S.: Partial cortical blindness with preservation of color vision. Arch. Ophthalmol. 9:957-965, 1933.

This is a report of a case following possible CO asphyxiation, whereby the patient suffered a brain lesion in which the cortex was extensively affected. It has been established by clinical observation and pathologic studies that cortical and subcortical lesions may give rise to dissociation of color perception from visual acuity, namely, loss of former without impairment of the latter; it is also well known that in impairment of vision, whether peripheral or central, the first to be lost and the last to be regained is the perception of color.

Author points out that CO has a predilation for the basal ganglious, especially causing lenticular softening, and for the peripheral nerves, but no part of nervous system is immune to the poison. Parkinsonian syndromes and peripheral nerve palsies frequently characterize CO poisoning. Mental deterioration and psychotic manifestations so commonly encountered attest the additional cortical involment, as well as Parkinsonian syndromes and peripheral nerve palsies. - AGC

STATE, CITY-COUNTY, AND INTER-STATE REPORTS

The State, City-County, and Inter-State reports are listed alphabetically by geographic location and some are briefly annotated.

These reports nearly always include a section dealing with the method of sampling and analysis of carbon monoxide. Some carry only a short reference but often there are graphs and charts of interest to the reader.

State Reports

Palomba, J., Jr., and Wromble, R.F.: An Appraisal of Air Pollution in Colorado. A report on cooperative survey by the Colorado State Dept. of Public Health and U.S. DHEW, Public Health Service, Nov. 1961-June 1962. Colorado State Dept. of Public Health, Denver, Colo., 1962, 27 pp.

Carbon monoxide emissions from internal combustion engines.

McCaldin, R.O., Kenline, P.A., and Wiggin, D.C.: Air Pollution in Connecticut. Report of a cooperative survey by the U.S. PHS and the Conn. State Dept. of Health, April-Sept. 1956, U.S. DHEW, PHS, RATSEC, Cincinnati, Ohio, 1957, 111 pp.

Motor vehicle registration and comparative fuel usage 1922-1955.

Bell, F.A., Jr., Beck, W.J., Shimp, J.H., and Welsh, G.B.: A Pilot Study of Air Pollution in Washington, D. C. Dept. of Public Health, District of Columbia and U.S. PHS, Div. Air Poll., Washington, D. C., Dec. 1960, 13 pp. and appendix.

Variations for gaseous (CO) and particulate matter constituents in comparison with meteorological conditions are given.

Welsh, G.B.: Air Pollution in the National Capital Area. An appraisal made at the request of the D. C. Dept. of Public Health, with cooperation of the Maryland State Dept. of Health and U.S. DHEW, PHS, Div. Air Poll., PHSP No. 955, July 1962, 41 pp.

Pollution from motor vehicles are discussed.

Lewis, R.P., McKee, S.B., Bell, F.A., and Carter, H.S.: Air Pollution in Georgia. A Cooperative Statewide Survey. Georgia Dept. of Public Health and U.S. DHEW, PHS, Cincinnati, Ohio, April 1962, 35 pp.

Air pollution measurement; maximum pollution levels (CO).

Metzler, D.F., Strella, G.G., and Doughty, L.C.: The Air of Kansas. A report on a survey by the Kansas State Board of Health with cooperation of the U.S. DHEW, PHS, Kansas State Board of Health, Topeka, Kansas, Sept. 1962, 91 pp.

Automotive fuel; control techniques.

An Appraisal of Air Pollution in Minnesota. A report on a survey by the Minnesota Dept. of Health with cooperation from the U.S. DHEW, PHS, Oct. 1959-July 1960. Minnesota Dept. of Health, Minneapolis, Minnesota, Jan. 1961.

Motor vehicle registration and gasoline consumption. Emission of air contaminants from gasoline powered vehicles.

A Study of Air Pollution in Seven Montana Cities July 1961-July 1962. The Montana State Board of Health, Division of Disease Control with partial support from Div. of Air Poll., U.S. DHEW, PHS, 104 pp.

Quantities of automobile and truck pollutants - yearly contributions are listed.

Air Pollution Control in New Jersey. A Progress Report of the New Jersey Air Poll. Control Commission including A Report of the Dept. of Health, Air Sanitation Program for the Period July 1, 1956 to Oct. 31, 1957. The New Jersey State Dept. of Health, Air-D8, 28 pp.

A Review of Air Pollution in New York State. New York State Air Pollution Control Board, July 1958, 76 pp.

Various special studies have been conducted suporadically throughout the State to investigate localized air pollution problems.

Blakeney, B., and High, M.D.: Cleaner Air for North Carolina. A Report of a Cooperate Survey. North Carolina Board of Health, Raleigh, North Carolina, Sept. 1959, 62 pp.

Motor vehicle registration and gasoline consumption growth in North Carolina.

McHard, J.D., and Wromble, R.F.: OK Air for the OK State. A Report on the Appraisal of Air Pollution in Oklahoma. Oklahoma State Dept. of Health in cooperation with U.S. DHEW, PHS, Div. of Air Poll. Oklahoma State Dept. of Health, Oklahoma City, Oklahoma, Jan. 1965.

NSA data depict Oklahoma as being one of the states with the least air pollution.

Anderson, D.M., Lieben, J., and Sussman, V.H.: Pure Air for Pennsylvania. A joint study of the extent and nature of air pollution in Pennsylvania. Pennsylvania Dept. of Health and U.S. PHS, Nov. 1961, 136 pp.

Combustion emissions, including CO are discussed.

Carl, C.E., and Christensen, G.L.: Appraisal of Air Pollution in South Dakota. A cooperate survey by the South Dakota State Dept. of Health and the U.S. PHS, Oct. 1961-May 1962. South Dakota State Dept. of Health, Pierre, South Dakota, Aug. 1962.

Amounts of pollutants emitted from automobiles for each 1000 gallons of gasoline burned are listed.

Kenline, P.A.: Appraisal of Air Pollution in Tennessee. Report of a Cooperative Survey by the U.S. PHS and the State of Tennessee Dept. of Public Health, Dec. 1956-July 1957. U.S. DHEW, PHS, Cincinnati, Ohio.

Fuel usage by type of fuel, class of consumer, and geographic area is discussed.

Paganini, O., High, M.D., and Kenline, P.A.: Appraisal of Air Pollution in Texas. Report of a cooperative survey by the Texas State Dept. of Health and the U.S. DHEW, PHS, Dec. 1957 through July 1958. Texas State Dept. of Health, Austin, Texas, 1958, 107 pp.

Purpose of this study, among others, was to determine the status of current air pollution problems and bring into proper perspective the overall situation.

Air Resources of Utah. A Report Submitted to the Utah Legislative Council of the Utah State Legialture. Utah Legislative Council, Air Pollution Advisory Committee, June 1962, 32 pp.

Survey of CO (tons/day) emitted by motor vehicles, industry and miscellaneous sources.

Hendrickson, E.R., Keagy, D.M., and Stockman, R.L.: Evaluation of Air Pollution in the State of Washington. Report of Cooperative Survey made July-Nov. 30, 1956. U.S. DHEW, PHS - State of Washington Dept. of Health. RATSEC, Cincinnati, Ohio, 1956, 145 pp.

Automobiles are the major contributor of pollution by transportation activities.

City-County Reports

Kreichelt, T., and Dahle, E.: Air Pollution Measurements in Baltimore, Md. March-April 1964. U.S. DHEW, PHS, Div. of Air Pollution, Cincinnati, Ohio, Nov. 1964, 60 pp.

Measurements were made at the TAB Mobile Lab in Baltimore by a continuous IR analyzer. Hourly averages ranged from 0.6 to 19.8 ppm CO. Frequency distribution are given.

Hochheiser, S., Horstman, S.W., and Tate, G.M., Jr.: A Pilot Study of Air Pollution in Birmingham, Alabama. A joint study by the City of Birmingham, Jefferson County Dept. of Health and U.S. PHS, Cincinnati, Ohio, RATSEC TR A62-22, May 1962, 54 pp.

Tabulation of carbon monoxide levels and meteorological measurements.

Keagy, D.M., and Schueneman, J.J.: Air Pollution in the Birmingham, Alabama Area. Prepared at the request of the Jefferson County, Alabama Dept. of Health and the City of Birmingham, Alabama and U.S. DHEW, PHS, RATSEC, Cincinnati, Ohio, May 1958, 71 pp.

Emission of pollutants from public consumption of fuel.

Basbagill, W.J., and Dellas, J.L.: Air Quality in Boston, Massachusetts, Nov.-Dec. 1963. U.S. DHEW, Div Air Poll., Cincinnati, Ohio, Nov. 1964, 51 pp.

Section on gaseous contaminants.

Welch, G.B., and Kreichelt, T.E.: Clean Air for Chattanooga. In cooperation with City of Chattanooga, Tenn. and the Tenn. Dept. of Public Health, Nashville, Tenn. U.S. DHEW, PHS, Div. of Air Poll., Cincinnati, Ohio, 1964, 49 pp. and appendix.

Air-monitoring activities are recommended to indicate trends in community air quality and to provide a better basis for development of pollutant emission regulations.

Kenline, P.A.: Air Pollution in Charleston, South Carolina. TR A60-6, U.S. PHS, Div. of Air Poll., Cincinnati, Ohio, 1960, 12 pp.

Report on Bi-State Study of Air Pollution in the Chicago Metropolitan Area. Conducted by Illinois Dept. of Public Health with technical assistance from U.S. DHEW, PHS, Cincinnati, Ohio, 1957-1959, 144 pp.

Medalia, N.Z., and Finkner, A.L.: Community perception of air quality: an opinion survey in Clarkston, Washington. PHSP No. 999-AP-10, 1965, 106 pp.

Mathews, D.S.: Management of Dade County's Air Resources. U.S. DHEW, PHS, in cooperation with Florida State Board of Health and Dade County Dept. of Public Health. Robert A. Taft Sanitary Eng. Center, Cincinnati, Ohio, Oct. 1962, 39 pp.

Carbon monoxide emissions are discussed.

Schueneman, J.J.: The Denver Area Air Pollution Problem. With cooperation of City and County of Denver Dept. of Health and Hospitals and Building Dept. and the Tri-County Health Dept. and U.S. DHEW, PHS, RATSEC, Cincinnati, Ohio, June 1957, 78 pp.

Use of automobiles and automotive fuels - Denver Metropolitan Area - are discussed.

Schrenk, H.H., Heimann, H., Clayton, G.D., Gafafer, W.M., and Wexler, H.: Air Pollution in Donora, Pennsylvania. Epidemiology of the Unusual Smog Episode of Oct. 1948. Preliminary Report PHB 306, U.S. PHS, Washington, D. C., 1949, 173 pp.

Investigation of atmospheric contaminants.

Hochheiser, S., Nolan, M., and Dunsmore, H.J.: Air Pollution Measurement in Duquesne, Pennsylvania Sept.-Oct. 1963. Allegheny County Health Dept., Bureau of Air Pollution Control, U.S. DHEW, PHS, Div. of Air Poll., Oct. 1964, pp. 34, CFSTI PB 167678.

This report deals with a detailed study conducted in and around Duquesne, Pa. Analysis was made by an IR unit in the Field Studies Branch Mobile Laboratory. Hourly averages in both studies ranged from highs of 20-25 ppm to 2-3 ppm baseline. Frequency distributions are given.

Air Pollution in El Paso, Texas Area. El Paso City-County Health Unit. Report on a Two Year Study Under a Community Air Pollution Demonstration Project Grant, U.S. DHEW, PHS, 1957-1959, 97 pp.

Tests for CO were made with a field test kit, using the "hoolamite" (activated iodine pentoxide) tubes which are sensitive to as low as five parts per million. Results of sampling for CO are shown in table.

Air Pollution in Erie County. Comprehensive Area Survey Report Number Two. State of New York, Air Pollution Control Board, Albany, N. Y., 1963, 101 pp.

Survey includes an inventory of emissions, studies of area meteorology, atmospheric contaminant concentrations, effects of air pollution and other factors.

Fresno Air Pollution Study. A Joint State-Federal Project. State of California Dept. of Public Health, Bureau of Air Sanitation, and Air and Industrial Hyg. Lab., Berkeley, California, July 1960, 20 pp.

Motor vehicle registration, gasoline consumption and pollution level of CO are discussed.

Air Pollution in Greater Elmira. A Survey Report. Area Survey No. 1. New York State Dept. Health, Air Pollution Control Board, 64 pp.

Comprehensive survey.

Kenline, P.A.: Air Pollution in Hamilton, Ohio. RATSEC TR A60-8, U.S. PHS, Div. of Air Poll., Cincinnati, Ohio, 1960, 12 pp.

Statistics on motor vehicles, sampling and measurement, industrial sources, commercial and domestic fuel consumption are discussed.

Welsh, G.B.: An Appraisal of Air Pollution in Huntsville, Alabama. In cooperation with City of Huntsville, Alabama, Madison County Health Dept., Alabama State Health Dept. and U.S. DHEW, PHS, Div. of Air Poll., Washington, D. C., May 1963, 21 pp.

Pollution from motor vehicles is discussed. Report is based on evaluation of existing data, observation of certain industrial operations and discussions with local officials.

Hochheiser, S., and Welzel, G.: Air Pollution Measurements in Indianapolis. June-July 1963. U.S. DHEW, PHS, Div. of Air Poll., Cincinnati, Ohio, July 1964, 64 pp.

Measurements were made in the stationary transportable laboratory of the Technical Assistance Branch by manual detector tubes. Values for 30 minute periods of up to 48 ppm were recorded. Values were highest during morning rush hour (8 AM).

Sheehy, J.P., Henderson, J.J., Harding, C.I., and Danis, A.L.: A Pilot Study of Air Pollution in Jacksonville, Florida. U.S. DHEW, PHS Pub. No. 999-AP-3, Div. of Air Poll., Cincinnati, Ohio, April 1963, 65 pp.

Estimated emissions of carbon monoxide in the Jacksonville area from various sources are discussed.

A Study of Air Pollution in the Inter-State Region of Lewiston, Idaho, and Clarkston, Washington. PHS Pub. No. 999-AP-8, Dec. 1964, 154 pp.

The purpose of the study was to determine the nature and extent of air pollution in the two-city area and to assemble information to be used as a basis for technical and official action needed to conserve air quality in the area.

The Air Over Louisville. Summary of a Joint Report by the Special Air Pollution Study of Louisville and Jefferson County, Kentucky, 1956-1957. U.S. PHS, Cincinnati, Ohio, 1958, 57 pp.

The Louisville Air Pollution Study. A Technical Report on the Joint Study of Air Pollution in Louisville and Jefferson County, Kentucky, 1956-1957. RATSEC TR A61-4, U.S. PHS, Cincinnati, Ohio, 1961, 172 pp.

Dyksterhouse, G.: Air Pollution in Lynchburg, Virginia. U.S. DHEW, PHS, Washington, D. C., Oct. 1961, 22 pp.

Air pollution emission rates.

A Pilot Study of Air Pollution in Lynchburg, Virginia, Feb. 9-15, 1961. A Cooperative Study by the City of Lynchburg and U.S. PHS, Lynchburg, Va., Feb. 1961, 22 pp.

Among others, sampling of carbon monoxide from motor vehicles and combustion processes. Adaptation of National Bureau of Standards detector tube technique.

Basbagill, W.J.: Air Contaminant Measurements at Roosevelt Field, Nassau County, New York. U.S. DHEW, PHS, Div. of Air Poll., July 1965, 48 pp.

Measurement of CO.

Hochheiser, S., and Burchett, M.: Air Pollution Measurements in Pittsburgh, Jan.-Feb. 1963. Allegheny County Health Dept., Bureau of Air Pollution Control and U.S. DHEW, PHS, Div. of Air Poll., Nov. 1963, 50 pp.

Gaseous pollutants - carbon monoxide are discussed. Concentration of this gas from motor vehicle exhaust varies from less than 1 to 10%.

Air Pollution in the Portland Metropolitan Area. A Report of the Oregon State Sanitary Authority - A Division of the Oregon State Board of Health, Sept. 1963, 43 pp.

No direct reference to CO. However pollution from fuel usage and motor vehicles are discussed and statistics given.

High, M.D., Slater, R.W., Jr., and Costantino, G.G.: A Pilot Study of Air Polltuion in Providence, Rhode Island. TR A62-15, U.S. PHS, Cincinnati, Ohio, June 1962, 44 pp.

The NBS detector tube technique was adapted as method of measurement for CO from motor vehicle exhaust and from combustion processes. Lowest CO level during sampling period 1 ppm, highest reading 6 ppm.

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AUTHOR INDEX

Numbers after each entry refer to the corresponding abstract, dates in parentheses to publication year.

Abe, M., 164 (1963)
-, Abe, T., 848 (1963)
Abramson, E., 473 (1944)
Abt, I.A., 165 (1922)
-, Accomazzo, M.A., 727 (1961)
Adams, E.G., 2 (1951)
Adler, A., 455a (1944)
-, -, Aeberly, J.J., 21 (1928)
-, Ajuriaguerra, D., 320 (1946)
Alekseeva, M.V., 736 (1960), -, 751 (1952)
Allen, T.H., 3 (1955), -, 288 (1953)
Almgren, S., 456 (1954)
Altshuller, A.P., 956 (1965)
Alvis, H.J., 754 (1952)
Ambrosio, L., 267 (1959)
-, -, Anderson, R.B., 635 (1964)
Anderson, T., 677 (1958)
Anson, M.L., 268 (1925)
-, Antonini, E., 289 (1958)
Apthorp, G.H., 344 (1961), -, -, 587 (1960), 588 (1955)
Arena, J.M., 167 (1963)
-, -, Armstrong, R.G., 476 (1965)
Arnold, H.R., 568 (1921)
Ash, S.H., 771 (1942)
-, Ashby, D.W., 340 (1961)
Asmussen, E., 269 (1941)
Audere, A.K., 781 (1959)
Austen, F.K., 206 (1962)
-, Awa, A., 451 (1962)
Ayen, R.J., 679 (1966)
Ayer, H.E., 5 (1959)
Ayres, S.M., 476 (1965)

Bacaner, M., 270 (1964)
-, Bachem, A., 569 (1930)
Baetjer, A.M., 208 (1950)
Bangert, F., 681 (1959)
-, Barcroft, H., 477 (1924)
Barcroft, J., 477 (1924), 478 (1925), -, 268 (1925)
Barth, R., 805 (1960)
Barrett, H.M., 804 (1934)
Basbagill, W.J., 737 (1964), -, -, 701 (1965)
-, Bascom, W., 658 (1953)
Bates, D.V., 345 (1952), -, -, 348 (1954), -, -, 349 (1954), 378 (1964)
Baulmer, J., 806 (1961)
Beard, R.R., 755a (1964)
Beatty, R.L., 6 (1955)
Beck, H.G., 146 (1936), 209 (1925), 210 (1927), 212 (1937), 301 (1938)
-, -, Beckman, A.O., 72 (1947)
-, Begeman, C.R., 20 (1965)
Beghe, R., 168 (1964)
Behnke, A.R., 254 (1943), -, -, -, 262 (1946)
Bell, M.A., 312 (1961)
-, Bellet, S., 302 (1944)
-, Belli, R., 896 (1955)
Belza, J., 335 (1955)
Berger, L.B., 7 (1938), 8 (1947), 772 (1940), -, 780 (1941), -, -, 56 (1923), 802 (1924), -, -, -, 163 (1930)
-, Bergeron, M., 337 (1963)
Bernhard, W.F., 271 (1964)
-, Bertin, M., 178 (1964)
Besson, A., 807 (1962)
Birren, J.E., 755b (1964), -, -, -, 767a (1964)
-, -, Bishop, J.M., 356 (1960)
Bjerver, K., 215 (1948)
-, -, Blakemore, W.S., 368 (1955), -, -, -, 350 (1955)
-, Block, W.D., 16 (1937)
Bloomfield, J.J., 808 (1928), -, 902 (1926)
-, Boerma, M., 809 (1966)
Bogatkov, P.I., 254a (1961)
Bokhoven, C., 416 (1961)
Bokonjić, N., 327 (1963)
Bolt, J.A., 809 (1966)
Boor, A.K., 569 (1930)
Borman, M.C., 171 (1926)
Bowden, C.H., 570 (1964)
Braja, M., 889 (1964)
-, Braverman, M.M., 54 (1959)
Breysse, P.A., 216 (1961)
Brice, R.M., 810 (1965)
Brief, R.S., 811 (1960)
Brieger, H., 481 (1944)
-, -, Briscoe, W.A., 350 (1955), -, -, -, 351 (1957)
Broering, L.C., Jr., 9 (1966)
-, Brubacher, M.L., 834 (1962)
Brumbaugh, I.V., 786 (1922)
-, Brunk, U., 297 (1964)
-, Bruno, P., 328 (1963)
Bryan, R.J., 642 (1965), 682 (1963)
-, Bulycheva, A.I., 118 (1956)
-, Bunker, N.V., 181 (1959)
Burck, H-C, 172 (1964)

Burda, A.S., 123 (1963)
Burrell, G.A., 147 (1914), 787 (1919)
-, -, Burton, J.E., 361 (1963)
-, Busch, K.A., 531 (i.p.)
-, -, Byrne, J.J., 360 (1965)
Byrom, R.D., 812 (1957)

-, -, Cadigan, J.B., 366 (1957), -, 582 (1957)
-, Cahill, J.M., 360 (1965)
-, Calvert, J.G., 59a (1965), 80 (1964)
Cambier, R., 738 (1928)
-, Cambruzzi, S., 192 (1958)
Campbell, J.A., 148 (1933), 149 (1935), 272 (1929), 438 (1930), 439 (1932)
Campbell, J.M., 621 (1964)
Campbell, O.F., 622 (1955)
-, -, Cander, L., 351 (1957), 370 (1957)
Candura, F., 124 (1961), 124a (1964)
Canter, H.G., 255 (1964)
-, Capellaro, F., 238 (1964)
Caplan, J.D., 813 (1965), 959 (1963)
Carey, G.C.R., 686 (1957), -, -, 372 (1960)
Carlo, S., 328 (1963)
Carlsen, E., 273 (1958)
Carlsten, A., 483 (1954)
-, Carrier, E.B., 568 (1921)
-, Carroll, D.C., 128 (1925)
Cartigny, S., 774 (1957)
Castellino, N., 484 (1959)
Castrop, V.J., 740 (1955)
-, Catcott, E.J., 518 (1962)
Chalupa, B., 381 (1960)
-, Chapek, A.V., 757 (1964)
Chass, R.L., 10 (1960)
Chernov, V.M., 150 (1947)
Chinn, H.I., 417 (1944), 571 (1944), 572 (1955)
Chiodi, H., 126 (1941), 269 (1941)
Chipman, J.C., 741 (1960)
Cholak, J., 11 (1952), 12 (1952), 13 (1954), 14 (1956), 14a (1957)
Chovin, P., 15 (1964), -, 77 (1958)
Chornyak, J., 127 (1931), -, 144 (1934)
-, -, -, Christensen, M.K., 332 (1961)
Christman, A.A., 16 (1937), 573 (1933)
Cier, 17 (1958)
Ciocatto, E., 174 (1964)
Ciuhandu, G., 18 (1957)
-, -, Clark, F., 340 (1961)
Clark, R.T., 151 (1949), 152 (1952), -, 415 (1959), 441 (1959) -, -, 162 (1959)
-, Clarke, E.R., 322 (1945)
Clarkson, D., 624 (1962)
Clayton, G.D., 19 (1960), 19a (1964)
-, Cobb, D.M., 442 (1932)
-, Cole, J.W., 92 (1947)
-, Commins, B.T., 120 (1965), 916 (1961)
Connolly, J.I., 21 (1928)
-, Cook, W.A., 19a (1964)
Clemens, J.B., 964 (1926)
-, Cohn, J.E., 350 (1955)
-, Cole, J.W., 92 (1947)
-, Coleman, F.C., 978 (1962)
Commins, B.T., 574 (1965), 788 (1957), -, 66 (1962)
-, Comroe, J.H., Jr., 273 (1958)
Conlee, C.J., 891 (i.p.)
Colucci, J.M., 20 (1965)
Colvin, L.T., 366 (1928)
-, Consolazio, W.V., 261 (1944), 262 (1946), -, -, 126 (1941), 254 (1943)
-, Cook, W.A., 19 (1960)
Cosby, R.S., 337 (1963)
Coscia, G.C., 273a (1964), -, 201 (1964)
Cotes, J.E., 345a (1962)
Courville, C.B., 176 (1964), 314 (1957)
-, Crane, R.A., 72 (1947)
-, Craveri, A., 124 (1961), 124a (1964)
Cribb, G.S., 626 (1959)
-, -, -, Criscuolo, D., 441 (1959)
Crosby, W.H., 575 (1954)
-, Crouse, W.R., 37 (1963)
-, -, -, Cruz, W.O., 616 (1946)
-, Cugell, D.W., 366 (1957)
Cumming, A.P.C., 627 (1951)
Cummins, R.L., 892 (1964), -, -, 891 (1966)
Curphey, T.J., 488 (1965)

-, Dahlstrom, H., 677 (1958)
Dales, S., 274 (1959)
-, Dallas, J.L., 737 (1964)
-, D'Arca, S., 22 (1956)
-, Darling, R.C., 549 (1944)
Datsenko, I.I., 275 (1964), 276 (1965)
-, Davenport, J.E., 31 (1935)
-, Davenport, S.J., 933 (1930)
Davies, G.M., 746 (1965)
-, -, -, Dawson, W.T., 250 (1926)
De Boer, S., 128 (1925)
De Bruin, A., 489 (1965)
-, -, De Graff, A.C., Jr., 358 (1965)
-, Degueldre, G., 774 (1957)
-, -, Delgado, E., 519 (1945)
-, -, DeLong, P.L., 531 (i.p.)
DelVecchio, V., 22 (1956), 23 (1958)
Demidov, A.V., 930 (1964)
-, -, De Silva, H., 498 (1937)
Desoille, H., 153 (1964)
-, Dill, D.B., 498 (1937), -, 126 (1941)
Di Lullo, G., 814 (1960)

-, Dodge, B.F., 106 (1947)
-, -, Doerr, R.C., 883 (1959)
Dollery, C.T., 346 (1960)
-, -, Domanski, T.J., 407 (1963)
Dominguez, A.M., 407 (1963), 503 (1959)
Dorcus, R.M., 256 (1929)
Douglas, C.G., 491 (1911), 492 (1912)
Douglas, T.A., 129 (1962), 577 (1962)
Drabkin, D.L., 578 (1948), 579 (1949), -, 155 (1944)
Drawin, H.W., 815 (1960)
Drinker, C.K., 924 (1938), -, 341 (1938), 396 (1936), 397 (1936)
DuBois, K.P., 925 (1959)
Dubois, L., 26 (1966)
Dunham, A.R., 692 (1934)
-, Dunlap, J.W., 467 (1953)
Dunlap, R., 420 (1961)
Duvoir, M., 219 (1946)
-, Dyson, N.A., 346 (1960)

Edell, G.M., 29 (1928)
Edwards, H.D., 628 (1960)
-, Edwards, T.I., 913 (1942)
Effenberger, E., 30 (1957), 816 (1958)
Ehrich, W.E., 302 (1944), 338 (1944)
-, Eilmann, H.J., 449 (1932)
-, -, Ellicott, M.F., 582 (1957)
Elliott, M.A., 775 (1955), -, 772 (1940), 777 (1941)
Ellis, J.P., 441 (1959)
End, E., 131 (1942)
Engstedt, L., 496 (1957)
Erdman, H., 817 (1960)
Evans, R.N., 31 (1935)
Evreux, R., 32 (1963)

Faith, W.L., 695 (1963), 818 (1963)
Farre-Rius, F., 33 (1964)
Fassina, L., 34 (1960)
-, Fati, S., 159 (1959), 284 (1957)
Fejér, G., 457 (1924)
Feldstein, M., 277 (1965), -, 68 (1964)
Fenimore, C.P., 630 (1957)
Fenn, W.O., 442 (1932)
-, Ferris, B.G., Jr., 914 (1963)
Fiandaca, S., 220 (1964)
Field, F., 35 (1962)
Fieldner, A.C., 894 (1926)
Filley, G.F., 347 (1954)
Fink, A.I., 458 (1951)
-, -, -, Finn, R., 593 (1962)
Fisher, B.M., 385 (1960)
-, Fisher, K.C., 274 (1959)
Fisher, M.B., 967 (1954), -, 755b (1964), -, -, 767a (1945)
Fitton, A., 821 (1955)
-, Flieger, K., 953 (1965)
Florentin, D., 36 (1928)
Flynn, N.E., 37 (1963)
-, Fodor, G., 394 (1963)
Forbes, J.J., 632 (1954)
Forbes, W.H., 498 (1937), 499 (1945)
*-, Fort, W., 209 (1925)
-, Fournier, Et., 329 (1964)
-, Fowler, W.S., 348 (1954), 349 (1954)
**-, Frank, E.R., 711 (1962)
-, -, -, Franke, R.E., 529 (1946), 530 (1946)
Frederick, R.C., 580 (1931)
-, -, Frederick, W.G., 19 (1960), 19a (1964)
-, Freimuth, H.C., 502 (1943)
-, -, Frevert, H.W., 705 (1926), 917 (1941)
Friberg, L., 651 (1965), 651a (1965)
-, Froboese, V., 845 (1930)
-, -, -, Fulton, W.B., 263 (1929)
Furlong, N.B., 581 (1957)
-, -, Furth, F.W., 575 (1954)

Gaensler, E.A., 351a (1966), 582 (1957), -, -, -, 360 (1965), 366 (1957)
-, Gaido, P.C., 797 (1964)
-, -, Garcia, R., 425 (1961)
-, Gardner, G.R., 101 (1965)
-, Gates, I., 250 (1926)
-, Gauger, A.W., 787 (1919)
Gaultier, M., 329 (1964), -, 219 (1946)
Gemzell, C.A., 500 (1958)
Gerard, P., 756 (1963)
Gettler, A.O., 501 (1933), 502 (1943)
Giacomo, P., 583 (1956)
-, Guillot, M., 583 (1956)
-, Giannelli, S., Jr., 476 (1965)
Gilbert, G.J., 386 (1959)
-, Glaser, G.H., 386 (1959)
-, Gilardi, F., 543 (1952)
Gilinskiy, V.A., 757 (1963)
-, Girbal, E., 807 (1962)
Giubileo, M., 823 (1957), 824 (1958)
Giuliani, V., 896 (1955)
Glantz, W.M., 503 (1959)
Gofmekler, V.A., 653 (1964), 825 (1963)
-, Goldbaum, L.R., 454 (1957)
-, Goldberg, L., 215 (1948)
Gonzales, T.A., 584 (1954)
Goosens, J.F., 827 (1958)
Gorbatow, O., 132 (1948)
Goldsmith, J.R., 40 (1960), 41 (1961), 42 (1963), 43 (1963), 44 (1964), 505 (1962), 655 (1964), 826 (1959), -, 47 (1961), 593 (1962), 661 (1960)

*Forster, R.E., 348 (1954), 349 (1954), 350 (1955), 351 (1957), -, 368 (1957), 370 (1957), -, -, 369 (1957), 357, (1962), -, -, -, 356 (1960)

**Francois, R.Ch., 178 (1964)

Gramer, L., 585 (1961)
-, Grant, E.P., 842 (1964)
Grant, G.A., 697 (1951)
-, Greenburg, L., 53 (1955)
-, -, Gregersen, M.I., 288 (1953)
Greig, J.D., 698 (1957)
Grigor'ev, Z.E., 388 (1955)
-, Grimes, M.D., 81 (1957)
-, Groff, W.A., 158 (1960)
Grollman, A., 928 (1960)
-, Grove, G.W., 632 (1954)
Gruber, C.W., 656 (1965)
Grudzinska, B., 330 (1963)
Grut, A., 223 (1949)
-, Guiochon, G., 33 (1964)
Gunderman, K.O., 828 (1964)
-, Gussey, P., 635 (1964)

Haagen-Smit, A.J., 646 (1965), 829 (1964)
Hackney, J.D., 506 (1961), 507 (1962), -, -, 43 (1963)
Haddon, W., Jr., 425 (1961)
Hagen, D.F., 830 (1962)
Haggard, H.W., 303 (1921), 445 (1922), 509 (1921), -, 516 (1922), 792 (1923), 899 (1921), 901 (1926), 930 (1943)
-, -, Haines, R.L., 697 (1951)
Hajek, F., 831 (1964)
Haldane, J., 510 (1895), 511 (1895), 586 (1895)
Haldane, J.B.S., 466 (1927), 512 (1913), -, -, 492 (1912)
-, Haldane, J.S., 491 (1911), 492 (1912)
Hall, D.A., 791 (1957)
-, Hall, G.V., 304 (1964)
-, Hall, R.L., 464 (1955)
-, -, Hall, W.A., 467 (1953)
Halperin, M.H., 460 (1947), 461 (1959)
-, Halstead, J.R., 407 (1963)
Hama, G.M., 832 (1950)
Hamilton, L.H., 352 (1965)
Hamming, W.J., 46 (1960)
-, -, Hanley, A., 713 (1959)
Hanson, H.B., 426 (1933)
Hanson, J.S., 353 (1961)
-, Hanst, P.L., 883 (1959)
-, Hara, Y., 164 (1963)
Hartridge, H., 515 (1912)
Hass, G.C., 833 (1961), 834 (1962), -, -, 644 (1961), 660 (1960)
-, Hastings, A.B., 426 (1933)
Hatch, T.F., 354 (1952)
Hayashi, S., 633 (1964)
Hayes, J.M., 304 (1964)
Hayhurst, E.R., 226 (1926)
Hechter, H.H., 47 (1961)
Heim, J.W., 758 (1939)
Heinen, C.M., 835 (1962)
-, -, -, Heinrich, B.J., 81 (1957)
Heller, A.N., 48 (1965)
Hellmann, C.S., 700 (1961)
Helmchen, H., 331 (1964)
Helminen, T., 462 (1954)
-, -, Helpern, M., 584 (1954)
-, -, Helwig, H.L., 593 (1962)
Henderson, M., 587 (1960), -, -, 66 (1962)
Henderson, Y., 179 (1916), 516 (1922), 792 (1923), 899 (1921), 901 (1926), 930 (1943), -, 509 (1921)
-, Hiller, A., 616 (1946)

-, Isbell, H.S., 808 (1928)
Ito, M., 278 (1960)

Jackson, R.C., 181 (1959)
Jackson, W.E., 840 (1965)
Jacobs, M.B., 53 (1955), 54 (1959)
-, Jacobs, W.A., 802 (1924)
Jay, B.E., 355 (1960), 618 (1960)
-, -, Jegier, Z., 903 (1959), -, 911 (1960)
Jeney, E., 55 (1959)
Jensen, D.A., 841 (1964), 842 (1964)
Jerzykowski, T., 134 (1963)
Joels, N., 279 (1961), 521 (1958)
Johnson, B.L., 703 (1965)
Johnson, D.M., 182 (1961)
Johnson, R.L., Jr., 356 (1960), 357 (1965), 358 (1965), -, 375 (1962)
-, Jones, A.R., 811 (1960)
Jones, G.W., 56 (1923), -, 630 (1957), 786 (1922), -, -, 598 (1923), 600 (1923), 894 (1926)
Jones, J.G., 523 (1962), -, 746 (1965)
-, -, -, Jones, R.H., 582 (1957)
Jones, R.S., 359 (1960)
Jouasset-Strieder, D., 360 (1965)
Jutze, G.A., 749 (1963)

Kanter, C.V., 57 (1964), -, -, 638 (1960)
Kaskan, W.E., 58 (1959)
Kattwinkel, R., 704 (1941)
Katz, M., 59 (1956), 228 (1958), 705 (1926), 902 (1926), 903 (1959), -, 697 (1951), -, -, 911 (1960)
-, Kaufman, G.A., 507 (1962)
Kauper, E.K., 843 (1965)
Kaye, S., 844 (1957)
Keeser, E., 845 (1930)
Kelly, R.G.C., 464 (1955)

-, Kenline, P.A., 891 (i.p.)
-, Kerr, D.H., 375a (1966)
Kerr, J.A., 59a (1965)
-, Khrustaleva, VA., 736 (1962)
Kilburn, K.H., 361 (1963)
-, -, Kilday, M.V., 100 (1955)
Killick, E.M., 229 (1948), 524 (1940)
-, King, B.G., 767a (1945),
  -, -, -, 755b (1964)
King, W.J., 846 (1962), -, -, 109 (1963)
Kinney, S.P., 904 (1923)
-, Kinsey, J.L., 761 (1953)
Kirichinskaya, I.A., 390 (1958)
Kirsberg, V.A., 60 (1961)
-, Kitzes, G., 108 (1958)
Klein, W.J., 706 (1948)
Kling, A., 847 (1939), -, 778 (1938)
Knapp, H., 465 (1880)
Kobayashi, Y., 848 (1963)
Konecci, E.B., 280 (1955)
-, Konopinski, V.J., 892 (1964), 905 (1962), 909 (1965), -, -, -, 891 (i.p.)
Kopa, R.D., 849 (1963)
Korenevskaya, E.J., 525 (1955)
Korth, M.W., 61 (1963), 62 (1964)
Kovnatskyy, M.A., 391 (1961)
Kraft, D., 63 (1963)
Kraut, H., 526 (1939)
Kreukniet, J., 362 (1962)
-, -, -, -, Kreuzer, F., 351 (1957)
Krogh, A., 363 (1910)
Krogh, M., 364 (1915), -, 363 (1910)
-, Kruger, P.D., 252 (1960)
-, -, Kruse, R.E., 726 (1964), 864 (1964), -, -, -, 878 (1965)
Kuley, C.J., 64 (1963)
-, Kunkel, H., 331 (1964)

Labonde, J., 850 (1965)
-, Lafontaine, A., 827 (1958)
Lamb, A.B., 708 (1919)
Lambertsen, C.J., 658 (1953)
Lamon, H.J., 759 (1960)
Lampert, F.F., 65 (1959)
-, Larson, A.T., 708 (1919)
Larsen, R.I., 851 (1966), 905 (1962), 972 (1962), -, 676 (1965), -, -, 909 (1965)
-, Lashier, H., 506 (1961), -, -, 507 (1962)
Lastochkin, P.N., 709 (1928)
-, -, Lawson, D.D., 129 (1962)
-, -, Lawson, W.H., Jr., 357 (1965)
Lawther, P.J., 66 (1962), 67 (1965), 588 (1955), 852 (1956), 853 (1965), -, 574 (1965), -, -, 120 (1965), 788 (1957), 916 (1961)
Leclerc, E., 589 (1946)
-, Ledingham, I., 129 (1962)
-, Lemoan, G., 112 (1959)
Lentz, E.C., 318 (1965)
-, -, Lesnini, D.G., 103 (1958)
Letourneau, L.S., 590 (1959)
-, -, Leung, S.W., 151 (1949)
Levaggi, D.A., 68 (1964)
Levine, B.S. (editor and translator),
  Book 1 (1960), 107, 113, 525, 709, 716, 751
  Book 2 (1960), 102
  Book 5 (1961), 286, 388, 390, 781
  Book 7 (1962), 118, 298, 561, 799
  Book 8 (1963), 105, 868
  Book 9 (1964), 667, 669
  Book 10 (1964), 930a
-, -, Levy, D., 332 (1961)
-, Levy, E., 917 (1941), -, -, 263 (1929)
Lewey, F.H., 155 (1944), -, -, 302 (1944)
Lewin, L., 931 (1920)
Lewis, B.M., 364a (1959)
Lhermitte, J., 320 (1946)
-, Liberman, S.S., 150 (1947)
Lies, K.H., 854 (1963)
Liesegang, W., 69 (1928)
Likhachev, A.D., 70 (1963)
Lilienthal, J.L., Jr., 528 (1945), 529 (1946), 530 (1946), 973 (1950)
Lindenberg, R., 332 (1961)
Linderholm, H., 365 (1957)
Lindgren, S.A., 230 (1961)
Lindsley, C.H., 710 (1949)
-, Linn, R.A., 300 (1960)
Linville, W., 638 (1960)
Litzner, St., 306 (1936)
-, Liu, S.H., 605 (1929), 606 (1930)
Lodge, J.P., 711 (1962)
Löhner, K., 712 (1960)
-, Long, C.W., 131 (1942)
-, Luche, R.G., 10 (1960)
-, Luchsinger, P.C., 255 (1964)
Ludwig, J.H., 856 (1962), -, 810 (1965)
Lumio, J.S., 231 (1948), 232 (1954)
-, Lunche, R.G., 57 (1964)
Luther, H., 857 (1960), 858 (1961)
Lutmer, R.F., 531 (i.p.)
Lykova, A.S., 859 (1953)
Lynn, D.A., 749a (1966)
-, -, Lynn, K., 506 (1961), -, -, -, 507 (1962)
Lysyj, I., 713 (1959)

McBay, A.J., 183 (1965)
McCabe, L.C., 71 (1955)
McConnell, J.W., 184 (1912)
McCormick, R.A., 860 (1962)
McCullough, J.D., 72 (1947)
-, McElroy, J., 413 (1957)

McFarland, R.A., 429 (1957), 430 (1964), 466 (1944), 467 (1953), 468 (1953), -, 385 (1960), 461 (1959), -, -, 460 (1947)
-, McGuire, J.K., 35 (1933)
-, MacIntosh, D.J., 347 (1954)
MacKenzie, V.G., 659a (1965), 863 (1965), 953 (1965)
McMichael, W.F., 864 (1964), 865 (1965), -, -, 878 (1965)
-, -, MacMillan, F.P., 197 (1965)
-, McMullen, T.B., 749a (1966)
-, McNeill, R.S., 369 (1957)
-, MacPhee, R.D., 46 (1960)
Maga, J.A., 644 (1961), 660 (1960), 661 (1960)
Mainardi, M., 339a (1964)
Malorny, G., 394 (1963)
Manita, M.D., 561 (1960), 825 (1963)
Mant, A.K., 185 (1960)
Mantell, C.D., 431 (1964)
Marchiaro, G., 135 (1964), -, 136 (1964)
-, Marcy, F., 738 (1928)
-, Margaglia, F., 139 (1964)
-, Margaria, E., 135 (1964)
Marks, A., 366 (1957), -, -, -, -, 582 (1957)
Marsh, A., 73 (1958)
-, Marsh, J.D.F., 626 (1959)
-, -, -, Marshall, K.L., 917 (1941)
Marshall, R., 367 (1958), -, 344 (1961)
-, Martinek, M.J., 21 (1928)
-, Massey, F., 239 (1962)
-, Massey, M.T., 741 (1960)
Massmann, W., 908 (1955)
Matthes, B., 866 (1961)
-, Mattice, M.R., 501 (1933)
Maurin, Gen., 778 (1938)
Mayer, J., 591 (1956)
Mayers, M.R., 534 (1946)
-, Mazza, V., 267 (1959)
-, Meade, F., 359 (1960)
Meda, E., 535 (1964)
Medaglini, E., 281 (1962)
Mehrstens, J.H., 74 (1907)
Meigs, J.W., 186 (1952), 536 (1948)
-, Menetrier, M.L., 850 (1965)
-, Merino, C., 519 (1945)
-, Meriwether, F.V., 241 (1922)
-, Middleton, D.C., 76 (1962)
Middleton, G.D., 340 (1961)
Middleton, J.T., 76 (1962), 714 (1963), -, 624 (1962)
-, Milijic, B., 243 (1959)
-, Miller, F.A., 791 (1957)
-, Miller, H.A., 361 (1963)
Millikan, G.A., 592 (1942)
Mills, C.A., 307 (1957), 434 (1957)
Milokostova, L.G., 868 (1960)
Minchin, L.T., 715 (1947)
-, Mingle, J.G., 722 (1966)
Miranda, J.M., 909 (1965)
Mokhov, L.A., 716 (1957), 930 (1964)
Molfino, F., 187 (1964)
Monaco, B., 795 (1964)
-, Monkman, J.L., 26 (1966)
Morando, A.E., 868a (1965)
Moore, H.E., 717 (1955)
-, Moore, R.C., 429 (1957)
Morgan, J.L., 537 (1955)
-, -, -, Morton, J.W., 368 (1957)
-, Moseley, A.L., 430 (1964)
Mosinger, M., 282 (1940)
Moureu, H., 77 (1958), 869 (1961), 870 (1964)
Mulay, A.G., 78 (1961)
-, Mullaney, O.C., 395 (1940)
-, Müller, H., 712 (1960)
-, Muller, R., 806 (1961)
-, Munn, J.I., 575 (1954)
Murphy, E.J., 79 (1961)
Murphy, S.D., 157 (1964)
-, -, Murray, A.L., 913 (1942)
-, Murray, C.D., 478 (1925)
Musselman, N.P., 158 (1960)

Nagarjunan, T.S., 80 (1964)
-, Naus, L.L., 771 (1942)
Navrotskii, V.K., 283 (1960)
-, Nebel, G.J., 775 (1955)
-, Nefedov, Yu.G., 254a (1961)
-, Neil, E., 279 (1961)
Nelson, K.H., 81 (1957)
-, -, Nerheim, N.M., 51 (1964)
-, Nesbitt, R.E.L., 425 (1961)
Neubuerger, K.T., 322 (1945)
Nevers, G.F., 796 (1959)
-, Ng, Yu-Sim, 679 (1966)
Nichols, G., Jr., 761 (1953)
Nicloux, M., 189 (1921)
-, Niessen, H.J., 416 (1961)
-, Niven, J.I., 460 (1947), -, -, 461 (1959)
-, -, -, Norman, J.N., 129 (1962)
Noro, L., 190 (1945), 132 (1948)
-, Nowak, S., 134 (1963)

-, -, -, -, -, Oberst, F.W., 158 (1960)
-, Oborin, N.A., 123 (1963)
O'Brien, H.R., 196 (1922), 598 (1923)
Ogilvie, C.M., 368 (1957)
-, O'Hara, C.L., 119 (1955)
Oppenheim, U.P., 719 (1958)
-, -, Orahovats, D., 478 (1925)

-, Otis, A.B., 151 (1949), 152 (1952)
-, -, Owen, H.R., 250 (1926)

Pace, N., 261 (1944), 262 (1946), 663 (1945), -, 545 (1945), -, -, -, 254 (1943)
-, Pannain, B., 333 (1963)
Parin, V.V. (editor), 757 (1963)
Paris, J., 191 (1964)
Parmeggiani, L., 192 (1958), 543 (1952)
Pattono, R., 136 (1964), -, 174 (1964)
-, Patty, F.A., 163 (1930), -, -, 144 (1934), 740 (1955)
-, -, Paul, W.H., 722 (1966)
Paulin, P., 83 (1959)
-, Pawel, N.E.R., 572 (1955)
Payne, J.Q., 871 (1952)
Pecora, L., 138 (1964), 284 (1957), 544 (1960)
Pecora, L.J., 285 (1959), 261 (1944)
Peffek, R., 193 (1965)
Pennels, N.E., 720 (1957), -, 622 (1955)
-, -, Perkins, N.M., 488 (1965)
-, Perla, V., 484 (1959)
-, Pernell, M.L., 617 (1955)
Perrelli, G., 84 (1964), -, 273a (1964)
Petri, H., 85 (1965)
Pfrender, R.E., 237 (1962)
-, Phair, J.J., 686 (1957), -, -, -, 372 (1960)
-, Pine, M.B., 528 (1945)
Pistone, S., 910 (1963)
Pitts, G.C., 545 (1945), -, -, 261 (1944)
-, -, Pomerat, C.M., 451 (1962)
-, -, Pomp, H., 394 (1963)
Porter, K., 86 (1962)
Porter, M.M., 307 (1957), 434 (1957)
Portheine, F., 87 (1959), 546 (1954), 872 (1959)
-, Portwich, F., 172 (1964)
-, Preziosi, T., 332 (1961)
-, Pribram, K., 755a (1964)
Primavesi, C.A., 873 (1964)
-, -, Prince, A.L., 901 (1926), -, -, -, 899 (1921)
-, -, Proemmel, D.D., 529 (1946), 530 (1946)
Prokhorov, IU.D., 286 (1959)
-, Pugh, L.G.C.E., 521 (1958)
Pukhov, V.A., 287 (1964)

Querci, M., 139 (1964)

Ramsey, T.L., 449 (1932)
-, Randall, E.L., 573 (1933)
Rankin, J., 369 (1957)
Raskin, N., 395 (1940)
-, -, Redmond, R.F., 572 (1955)
Regan, C.J., 874 (1932)
Reid, R.S., 722 (1966)
Rennie, R.P., 911 (1960), -, 903 (1959)
Renzetti, N.A., 875 (1956), -, 818 (1957)
-, Reynolds, D.A., 705 (1926)
-, -, -, Rhodes, R., 361 (1963)
-, Riberdy, R., 59 (1956)
Ricci, C., 238 (1964)
Rice, E.W., 89 (1952)
Rihm, A., Jr., 90 (1965)
-, -, Riley, E.C., 791 (1957)
-, Riley, R.L., 529 (1946), 530 (1946), -, -, -, -, 350 (1955)
Ringold, A., 593 (1962)
Rispler, L., 875a (1965)
-, Robbe, H., 500 (1958)
Roberts, W.C., 548 (1952)
-, -, Robertson, I.W., 147 (1914)
-, Robscheit-Robbins, F.S., 615 (1927)
-, Rochette, J., 282 (1940)
-, Rogers, L.H., 826 (1959), -, -, 818 (1963)
Rokaw, S.N., 239 (1962)
Root, W.S., 288 (1953), -, 3 (1955), 551 (1945), 596 (1945)
Rose, A.H., Jr., 876 (1961), 877 (1962), 878 (1965), -, 726 (1964), 865 (1965), 882 (1966)
-, Rosettani, E., 84 (1964)
-, Ross, C.R., 875a (1965)
Roughton, F.J.W., 290 (1945), 370 (1957), 549 (1944), 550 (1945), 551 (1945), 595 (1934), 596 (1945), -, 351 (1957), 466 (1944), 602 (1942), 603 (1943), -, -, 499 (1945), -, -, -, 460 (1947), 461 (1959)
Rounds, D.E., 451 (1962), -, -, 775 (1955)
-, Rovida, S., 868a (1965)
Rowan, T., 978 (1962)
Rozera, G., 159 (1959)
-, Rozov, A.A., 286 (1959)
Rubino, G.F., 141 (1964)
Ryazanov, A.V., 665 (1959), 666 (1962), 667 (1960), 751 (1952)
Rylander, R., 651 (1965), 651a (1965)

Sakabe, H., 91 (1960)
Sakurai, Y., 552 (1963)
Salen, E.B., 240 (1946)
Salsbury, J.M., 92 (1947)
-, Saltzman, B.E., 5 (1959)

-, Salvesen, H.A., 614 (1919)
-, -, -, Sands, J., 478 (1925)
-, Sargent, F., 499 (1945)
Savicevic, M., 243 (1959)
Sayers, R.R., 196 (1922), 241 (1922), 263 (1929), 597 (1923), 598 (1923), 599 (1923), 600 (1923), 601 (1925), 933 (1930), -, 127 (1931), -, -, -, -, 144 (1934)
-, Schafer, L.J., 12 (1952), 14 (1956), 14a (1957)
-, -, -, Scherberger, R.F., 791 (1957)
-, -, -, -, -, Schiette, F., 593 (1962)
Schleusing, G., 452 (1964)
Schlipköter, H.W., 879 (1965)
Schmitt, F.O., 453 (1934)
-, -, -, Schneider, G.R., 51 (1964)
Scholander, P.F., 602 (1942), 603 (1943)
Schönbauer, L., 160 (1963)
Schrenk, H.H., 94 (1950), 604 (1942), 780 (1941), -, 7 (1938), -, -, 144 (1934), 163 (1930), -, -, -, 772 (1940)
-, Schuhmann, S., 100 (1955)
Schulte, J.H., 555 (1963), 762 (1961), 763 (1964)
-, -, Schultz, J., 16 (1937)
Schütze, W., 291 (1927)
-, Schwartz, R.G., 717 (1955)
-, Scott, M.G., 453 (1934)
-, -, -, Scott, W.E., 883 (1959)
-, Seanlin, J.R., 841 (1964)
-, Seddon, H., 448 (1966)
-, Seibert, F.M., 147 (1914)
-, Semerak, C.B., 317 (1918)
-, -, Senderikhina, D.Ya., 751 (1952)
Sendroy, J., Jr., 605 (1929), 606 (1930), 606a (1932)
Serra, C., 333 (1963)
Serruys, M., 723 (1959), 724 (1963)
Shafer, N., 197 (1965)
-, -, -, Shaffer, N.R., 10 (1960)
Shapritskii, V.N., 96 (1964)
-, Sharp, G.R., 199 (1960)
Sharrah, J.S., 752 (1954)
Shaughnessy, T.J., 341 (1938), 396 (1936), 397 (1936)
-, Shaw, D.B., 378 (1964)
Shaw, J.H., 97 (1953), 98 (1959)
Shepherd, M., 99 (1947), 100 (1955)
Shephard, R.J., 371 (1958), 372 (1960), -, -, 686 (1957)
Shillito, F.H., 396 (1936), 397 (1936)
Shtrum, I.Ya., 292 (1938)
Shulga, T.M., 669 (1961), 670 (1965)
Shumway, E.A., 244 (1925)
Sievers, R.F., 913 (1942)
Sigsby, J.E., Jr., 62 (1964)
-, Sigworth, H.W., 871 (1952)
Silverman, L., 101 (1965)
-, Simmons, N.T., 2 (1951)
-, -, Sinclair, J.D., 346 (1960)
Siösteen, S.M., 607 (1951)
Sjöstrand, T., 293 (1949), 294 (1952), 295 (1952), 296 (1952), 609 (1951), -, 607 (1951), -, -, -, 483 (1954)
Sklenovsky, A., 325 (1964)
Sköld, G., 297 (1964)
Skvortzova, N.N., 102 (1960)
Slusher, G.R., 764 (1964)
-, Smilay, M.G., 197 (1965)
Smith, A.M., 881 (1961)
-, -, Smith, D.E., 81 (1957)
Smith, G., 199 (1960), 981 (1964)
-, -, Smith, H.P., 568 (1921)
-, Smith, J.R., 352 (1965)
Smith, P.K., 557 (1945)
Smith, R., 726 (1964), 864 (1964), 877 (1962), 878 (1965)
Smith, R.N., 103 (1958)
-, -, Sobecki, M.F., 326 (i.p.)
Sobolev, G.K., 104 (1958)
-, Soda, R., 91 (1960)
-, Sokolova, T.I., 298 (1957)
Solvsteen, P., 373 (1965), 374 (1965)
Sorakina, S.F., 105 (1963)
Sourirajan, S., 727 (1961)
Spector, N.A., 106 (1947)
Speert, H., 766 (1946)
Speizer, F.E., 914 (1963)
Spencer, T.D., 142 (1962)
Spicer, W.S., Jr., 375 (1962), 375a (1966), -, 356 (1960)
-, -, -, Spier, C., 506 (1961)
-, Spiller, W.G., 184 (1912)
Stahman, R.C., 882 (1966), -, 876 (1961)
Stearns, W.H., 341 (1938)
Stembridge, V.A., 454 (1957), -, 503 (1959)
Stepanovich, A., 107 (1955)
Stephens, E.R., 883 (1959)
-, Stephens, J.F., 740 (1955)
Stern, A.C., 671 (1964), 672 (1965), 673 (1965), 728 (1963), 753 (1963), 884 (1965), 936 (1962), 937 (1962)
Sterz, H., 558 (1963)
Stevens, A.M., 246 (1926)
-, -, Stevenson, H.J.R., 876 (1961)
-, Storlazzi, M., 701 (1965)
-, Straub, A.A., 894 (1926)
Strecker, E.A., 398 (1927)
-, Strong, A.A., 703 (1965)
-, Struck, J.H., 881 (1961)
Strzelczyk, P., 247 (1964)
Sturrock, P.E., 108 (1958)
-, Suter, G.M., 301 (1938)

-, Suter, G.M., 301 (1938)
Swartz, D.J., 109 (1963), -, -, 846 (1962)
Sweeney, M.P., 729 (1965)
-, Swinehart, J., 103 (1958)
-, Szendrey, S., 55 (1959)

-, Tabakin, B.S., 353 (1961)
-, Tabor, E.C., 749 (1963)
-, Taft, A.E., 398 (1927)
Takahashi, K., 342 (1961)
Tamas, A., 413 (1957)
-, Tanner, C.W., 754 (1952)
Taylor, G.J., 110 (1964)
-, Taylor, H.F., 357 (1965), 358 (1965)
-, Taylor, J.R., 642 (1965), -, -, 46 (1960)
-, Taylor, W.F., 280 (1955)
Teague, M.C., 885 (1920), -, -, 899 (1921), -, -, -, 901 (1926)
Tebbett, R.W., 111 (1962)
-, -, -, Terrill, R.E., 326 (i.p.)
-, Terzaghi, J., 43 (1963)
Thiebault, R., 885a (1965)
-, Thompson, W.G., 964 (1926)
-, -, -, Thomson, M.L., 686 (1957)
Tiunov, L.A., 298 (1957), 299 (1963)
-, Tomashefski, J.F., 162 (1959)
T[illegible]e, O., 248 (1965)
-, -, Tow, P.S., 10 (1960)
Trinkina, I.A., 414 (1960)
Trompeo, G., 797 (1964), 798 (1964), -, 889 (1964)
Tronzano, L., 201 (1964)
-, -, Trostel, L.J., 902 (1926)
-, Truffert, L., 153 (1964)
Truhaut, R., 112 (1959), 674 (1964)
Turkel'taub, N., 113 (1950)
-, Turletti, G., 798 (1964)
Turner, J.W.A., 202 (1964)
-, Turner, M.E., 372 (1960)
Tyler, H.W., 915 (1956)

-, Ulrich, C.E., 326 (i.p.)
Ulrich, S.S., 114 (1953)
-, -, -, Umberger, C.J., 584 (1954)

Val'chuk, N.K., 799 (1959)
-, Vance, M., 584 (1954)
Vanderwerf, D., 115 (1964)
-, -, -, Van Deventer, F.M., 498 (1937)
-, -, -, Van Lingen, B., 349 (1954)
Van Slyke, D.D., 614 (1919), 615 (1927), 616 (1946), 731 (1917), 732 (1918), -, -, 605 (1929)
-, Vasil'ev, G.A., 299 (1963)
Vasil'eva, A.A., 561 (1960)
Vaskevich, D.N., 118 (1956)
-, Vecchione, C., 544 (1960)
-, Vercellotti, E., 220 (1964)
-, Visser, B.F., 362 (1962)
Vol'fson, Z.G., 675 (1952)
Vollmer, E.P., 264a (1945), 767a (1964), -, -, 214 (1964), 755b (1964)
-, Volman, D.H., 86 (1962)
Von Oettingen, W.F., 939 (1944)
-, Vroege, D., 489 (1965)
Vylomov, V.S., 733 (1948)
Vyskocil, J., 203 (1957)

Waggoner, J., 617 (1955)
Walker, J.K., 119 (1955)
Waller, R.E., 120 (1965), 916 (1961), -, 788 (1957)
-, Walters, D.F., 48 (1965)
-, Walters, D.H., 523 (1962)
Walters, F.M., 161 (1927)
-, -, Warner, C.G., 746 (1965)
Wechsler, I.S., 470 (1933)
-, -, -, -, Weeks, M.H., 158 (1960)
-, Weigand, G.E., 256 (1929)
-, -, Weisiger, J.R., 616 (1946)
-, -, -, -, Weiss, R., 478 (1925)
West, J.B., 376 (1962)
-, -, -, Whipple, G.H., 568 (1921)
White, A.J., 940 (1952)
White, J.J., 563 (1932)
-, White, W.A., 254 (1943), -, -, 262 (1946)
-, -, -, Wilinski, F.T., 158 (1960)
Wilke, H., 122 (1962)
Wilkins, E.T., 886 (1956)
Wilks, S.S., 162 (1959), 415 (1959), 769 (1963), 770 (1963), -, -, 280 (1955), 441 (1959)
-, -, Willey, G.F., 398 (1927)
-, Williams, G.C., 51 (1964)
Williams, L.A., 300 (1960)
Wilmer, W.H., 471 (1921)
Wilson, E.D., 250 (1926)
-, Wilson, K., 846 (1962)
-, Wilson, K.W., 109 (1963)
Wilson, R.H., 618 (1960), -, 355 (1960)
-, Witt, D.B., 165 (1922)
Wolfson, Z.G., 887 (1948)
-, -, Wong-Woo, H., 644 (1961)
-, Woodhall, W.R., 570 (1964)
Woodruff, R.S., 564a (1960)
Woolf, G.R., 377 (1964)
-, Wright, G.W., 351a (1966), -, -, 347 (1954)
-, -, -, -, Wunderlich, R.M., 899 (1921)

Xintaras, C., 326 (i.p.), -, 860 (1962), -, -, 518 (1962)

Yanov, A.P., 640a (1961)
Yant, W.P., 144 (1934), 163 (1930), 802 (1924), 917 (1941), -, 56 (1923), 263 (1929), 597 (1923), 599 (1923), 600 (1923), 601 (1925), -, -, 241 (1922), -, -, -, 589 (1923)
Yarrow, T.J., Jr., 251 (1902), 734 (1900)
Yeager, D.W., 14 (1956), 14a (1957)
-, -, Yevich, P.P., 158 (1960)
-, -, Yoder, J.D., 811 (1960)
Yoe, J.H., 92 (1947), 710 (1949)
Young, W.A., 378 (1964)
-, -, -, Younker, W.J., 14a (1957)

Zaffiri, O., 204 (1964)
-, -, Zak, B., 300 (1960)
-, Zannini, D., 187 (1964)
-, Zarembo, J.E., 718 (1959)
-, Zenk, H., 247 (1964)
Zimmer, C.E., 676 (1965)
Zorn, H., 205 (1964), 252 (1960), 253 (1964)

GEOGRAPHIC LOCATION INDEX

Numbers after each entry refer to the corresponding abstract, dates in parentheses to publication year.

United States

California, 57 (1964), 71 (1955), 110 (1964), 451 (1962), 619 (1955), 624 (1962), 636 (1964), 643 (1960), 644 (1961), 654 (1962), 660 (1960), 661 (1960), 662 (1962), 714 (1963), 735 (1962), 740 (1955), 742 (1965), 842 (1964), 843 (1965), 846 (1962)
Colorado, 865 (1965)
Illinois, 21 (1928)
Massachusetts, 905 (1962)
Michigan, 19 (1960), 19a (1964), 20 (1965), 740 (1955)
New York, 53 (1955), 534 (1946), 773 (1936), 899 (1921), 917 (1941)
Ohio, 12 (1952), 14a (1957), 97 (1953), 98 (1959), 744 (1965)
Pennsylvania, 840 (1965)
U.S. Cities, 749a (1966), 864 (1964), 865 (1965), 878 (1965)
Washington, 915 (1956)

Foreign

Austria, 160 (1963)
Belgium, 640 (1965), 827 (1958)
Canada, 59 (1956), 180 (1963), 228 (1958), 727 (1961), 911 (1960)
Czechoslovakia, 193 (1963), 381 (1960), 831 (1964)
England, 52 (1957), 58 (1959), 67 (1965), 73 (1958), 104 (1959), 111 (1962), 120 (1965), 142 (1962), 166 (1962), 181 (1959), 199 (1960), 200 (1962), 202 (1964), 229 (1948), 268 (1925), 448 (1966), 574 (1965), 527 (1956), 588 (1955), 627 (1951), 628 (1960), 691 (1962), 803 (1956), 821 (1955), 853 (1965), 886 (1956), 916 (1961)
Finland, 236 (1945)
France, 15 (1964), 17 (1958), 32 (1963), 34 (1960), 36 (1928), 77 (1958), 83 (1959), 112 (1959), 153 (1964), 191 (1964), 219 (1946), 320 (1946), 329 (1964), 539 (1961), 583 (1956), 589 (1946), 626 (1959), 639 (1964), 723 (1959), 724 (1963), 738 (1928), 774 (1957), 788 (1957), 807 (1962), 850 (1965), 869 (1961), 870 (1964), 885 (1965)
Germany, 27 (1960), 30 (1957), 49 (1963), 63 (1963), 69 (1928), 74 (1907), 85 (1965), 87 (1959), 122 (1962), 172 (1964), 203 (1957), 205 (1964), 247 (1964), 248 (1965), 282 (1940), 291 (1927), 306 (1936), 331 (1964), 452 (1964), 465 (1880), 526 (1939), 546 (1959), 558 (1963), 567 (1964), 585 (1961), 681 (1959), 704 (1941), 712 (1960), 805 (1960), 816 (1958), 817 (1960), 845 (1930), 854 (1963), 857 (1960), 858 (1961), 866 (1961), 872 (1959), 873 (1964), 879 (1965), 908 (1955), 931 (1920)
Holland, 33 (1964), 362 (1962), 419 (1965)
Hungary, 55 (1959)
Italy, 22 (1956), 23 (1958), 84 (1964), 124 (1961), 136 (1964), 137 (1960), 138 (1964), 139 (1964), 141 (1964), 159 (1959), 168 (1964), 174 (1964), 178 (1964), 187 (1964), 192 (1958), 201 (1964), 204 (1964), 220 (1964), 235 (1962), 238 (1964), 267 (1959), 273a (1964), 284 (1957), 285 (1959), 328 (1963), 339a (1964), 482 (1964), 484 (1959), 533 (1964), 535 (1964), 543 (1952), 544 (1960), 795 (1964), 797 (1964), 798 (1964), 814 (1960), 823 (1957), 868a (1965), 889 (1964), 896 (1955), 910 (1963)
Japan, 91 (1960), 164 (1963), 278 (1960), 342 (1961), 343 (1961), 552 (1963), 633 (1964), 848 (1963), 970 (1964),
Jugoslavia, 243 (1959)
New Zealand, 427 (1962), 678 (1965)
Poland, 134 (1963), 330 (1963), 733 (1948)
Romania, 690 (1957)
Scandinavian Countries, 4 (1958), 223 (1949), 231 (1948), 236 (1945), 240 (1946), 293 (1949), 294 (1952), 295 (1952), 296 (1952), 297 (1964), 363 (1910), 364 (1915), 365 (1957), 456 (1954), 483 (1954), 607 (1951), 608 (1948), 609 (1951)
Switzerland, 33 (1955), 806 (1961)
U.S.S.R., 24 (1962), 60 (1961), 65 (1959), 70 (1963), 96 (1964), 102 (1960), 105 (1963), 107 (1955), 113 (1950), 118 (1956), 123 (1963), 150 (1947), 276 (1965), 283 (1960),

U.S.S.R. (cont.), 286 (1959), 287 (1964), 292 (1938), 298 (1963), 390 (1958), 391 (1961), 414 (1960), 525 (1955), 561 (1960), 640a (1961), 653 (1965), 664 (1952), 665 (1959), 666 (1962), 667 (1964), 669 (1961), 670 (1965), 675 (1952), 709 (1928), 716 (1957), 736 (1960), 757 (1963), 781 (1959), 799 (1959), 825 (1963), 859 (1953), 868 (1960), 887 (1948)

GLOSSARY OF ABBREVIATIONS

A.	Association
AFB	Air Force Base
A. I. Ch. E. J.	American Institute of Chemical Engineers Journal
AIME	American Institute of Mining, Metallurgical and Petroleum Engineers (Metallurgical Society).
AISI	American Iron and Steel Institute
APCA	Air Pollution Control Association Abstracts. Published by the Air Pollution Control Association in Cooperation with the U.S. Public Health Service and the Library of Congress.
APCD	Air Pollution Control District
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTME	American Society of Tool and Manufacturing Engineers
ATZ	Automobiltechnische Zeitschrift (Journal of Motor Vehicle Technology)
BAAP	Biological Aspects of Air Pollution, an Annotated Bibliography by Heimann, H., Brooks, H.M., Jr., and Schmidt, D.G. Federal Security Agency, PHS, Div. of Industrial Hygiene, Washington, D.C., April 1950.
BMB	Davenport, S.J., and Morgis, G.G. : Air Pollution. A Bibliography. Bureau of Mines Bulletin 537, 1954.
CBK	Clara B. Kirkman
CEGB	Central Electric Generating Board
CERL	Central Electric Research Laboratory
CFSTI	Clearinghouse for Federal Scientific and Technical Information
CIDITVA	Center international de documentation sur l'inspection de la technique des vehicules automobiles.
CSIR	Council on Scientific and Industrial Research
DDC	Defense Documentation Center
Dept.	Department
Dept. Pub. Health	Department of Public Health
Div.	Division
IEE	Institute of Electrical Engineers
i. p.	In Press
IR	Information Report
ISA	Instrument Society of America
KTT	Annotated Bibliography. The Effects of Atmospheric Pollution on the Health of Man, 1957. The Kettering Laboratory, University of Cincinnati, Cincinnati, Ohio
LC	Library of Congress
LEPS	Laboratory of Physical Sciences (U.S. DHEW, PHS, Div. Air Pollution, Cincinnati, Ohio)

NASA	National Aeronautic and Space Agency Bibliography
Nat. Acad. Sc.	National Academy of Sciences
NBS	National Bureau of Standards
NBSR	National Bureau of Standards Reports
NCI	National Cancer Institute
Nat. Res. Council	National Research Council
PHS	Carbon Monoxide and its Relation to Traffic Accidents. U.S. PHS Grant RG 5676., 1964
PHSB	Public Health Service Bulletin
PHSP	Public Health Service Publication
Proc.	Proceedings
RI	Report of Investigation
Res.	Research
SAE	Society of Automotive Engineers
SME	Society of Mining Engineers
SPE	Society of Petroleum Engineers
SRI	Stanford Research Institute
TR	Technical Report
USBM	U.S. Bureau of Mines
USBMRI	U.S. Bureau of Mines Report of Information
USBMTP	U.S. Bureau of Mines Technical Paper
USDAB	U.S. Department of Agriculture Bulletin
USDATB	U.S. Department of Agriculture Technical Bulletin
USDC	U.S. Department of Commerce
USDHEW	U.S. Department of Health, Education, and Welfare
USDI	U.S. Department of the Interior
USNBS	U.S. National Bureau of Standards
USPHS	U.S. Public Health Service
WHO	World Health Organization
WSL	Warren Spring Laboratory

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Bibliography No. 68